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Leptodora Kindtii (Focke): Seasonal Population Abundance and Food Web Interactions in Lake Ontario; 1984, 1986, and 1987

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LEPTODORA KINDTII (FOCKE):

SEASONAL POPULATION ABUNDANCE AND FOOD WEB INTERACTIONS IN LAKE ONTARIO; 1984, 1986, AND 1987.

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BIOGRAPHICAL SKETCH

Joutje A. Koapaha was born , in Manado, Indonesia. He graduated from Rex Mundi High School in 1976 and entered Sam Ratulangi University in 1977. In 1979, he attended Morris Cerrullo School of Ministry in San Diego, California. In September 1984, he graduated with a degree in Agricultural Engineering from Sam Ratulangi University, Indonesia. Subsequently, he was appointed instructor at the Institute of Teacher School Training (IKIP Manado) and the Sam Ratulangi University.

While pursuing his degree in Agricultural Engineering at Sam Ratulangi University, he was elected vice president of the Student Senate, was a founder and the chairperson of Bantik Student & Youth Society, and was the president of the National Kosgoro Student Movement. In 1985, he was elected president and the chair of the department of the LVRI Pemuda Panca Marga Manado (National Youth Board of Indonesian Veteran) and the Indonesian Youth National Committee Board (KNPI-SULUT), respectively.

In January 1986, he was a founder and principal of Kosgoro High School Bengkol while lecturing at the IKIP Manado and Sam Ratulangi University. In August 1986, he won the Overseas Graduate Scholarship Program provided by the Indonesian Government and attended the English Language Internship Course at the SUNY Buffallo. In January 1987, he began a Master of Science degree program in Aquatic Ecology at the SUNY Brockport.

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ARIEL'S PEPPERONI

Whosoever shall seek to save his life shall lose it;
and whosoever shall lose his life for THE TRUTH
shall preserve it (Luke 17:33).............

Cursed be the man that trusteth in man,
and make flesh his arm, and whose
heart departeth from the LORD
(Jeremiah 17:5).....

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ABSTRACT

In 1984, 1986, and 1987 five stations in Lake Ontario off Sandy Creek were sampled biweekly to determine the abundance and biomass of the zooplankton *Leptodora kindtii* (Focke) and its links in the food web. The seasonal abundance and distribution of *Leptodora kindtii* in Lake Ontario were governed by temperature and productivity of habitat. The minimum temperature which *Leptodora kindtii* occurred in Lake Ontario was 6.0 ^{o}C. The highest abundance occurred proportionally with the highest temperatures in the months of late July and August. The population is mostly comprised of the female *Leptodora* during this period. The first appearance of males *Leptodora* in Lake Ontario occurred in mid-August and their numbers gradually increased with time.

Leptodora kindtii is a multivoltine organism which does not have a clearly separable cohort. Average abundance of *Leptodora* at the nearshore station ranged from 26.5 *Leptodora*/m^3 in 1984, 2.8 and 31.7 *Leptodora*/m^3 (inside and outside the Brockport Water Intake Plant, respectively) in 1986, and zero in 1987. The average abundance for the offshore station ranged from 9.8 *Leptodora*/m^3 in 1984 to 28.7 *Leptodora*/m^3 in 1987.

There was a positive correlation between alewife abundance and *Leptodora* abundance over several years of varying forage fish abundance. This suggests that alewife do

not affect *Leptodora* abundance in Lake Ontario, which is contrary to the results of previous studies in other lakes.

INTRODUCTION

Sebestyen (1960) identified Leptodora as a giant in the plankton community and the top planktonic predator. The population dynamics of Leptodora kindtii in the Great Lakes is not as well known as many other crustaceans such as Daphnia, Bosmina, Ceriodaphnia, Diaphanosoma, Cyclopoida, and Calanoida.

The abundance of Leptodora kindtii (Focke) varies in all of the Great Lakes. The annual average abundance was $2449/m^3$ in Lake Erie (Rolan et al. 1973), $200/m^3$ in Lake Michigan (Steward 1974), and less than $1/m^3$ in Lake Superior (Selgeby 1975a). In Lake Ontario, McNaught and Buzzard (1973) reported an average annual abundance of Leptodora kindtii of $34/m^3$ in the littoral zone (near Oswego) between August-October, 1969 and between July-August, 1970. Watson and Carpenter (1974) and Czaika (1974) with a more representative data set of Lake Ontario observed an average annual abundance of $41.9/m^3$ and $27.7/m^3$, respectively.

Understanding the complex interactions within lake communities and their effects on energy flow community structure is essential for effective management of lake systems (Carpenter 1988). Changes at the top of the lake food web structure may have observable manifestations four or five trophic levels below (Scavia and Fahnenstiel 1988). In Lake Michigan, Evans (1986) and Scavia et al. (1986) observed an increase in abundance of a larger zooplankton as a result of the decline of the predominant planktivore alewife. In a Connecticut lake (Brooks and Dodson 1965), Lake Michigan (Wells 1970), and Adirondack lakes (Hutchinson 1972), Leptodora's population was severely reduced due to size-selective feeding of planktivorous alewife. In Lake Ontario, Shea (1987) suggested that changes in the Lake's food web structure and its function are possible with introduction of exotics or stocking of native fish such as salmonines.

In Lake Ontario, the stocking of salmonines has increased substantially, from 304,000 individuals in 1968 to over 8 million in 1986 (Daniels and LeTendre 1987). Alewife (A. pseudoharengus) and rainbow smelt (Osmerus mordax) are the major forage of salmonines (Brandt 1986; O'Gorman 1987). Thus alewife, which are known to switch toward larger-sized prey such as Mysis, Pontoporeia, and Gammarus when available (Iancu 1987), may affect zooplankton abundance and composition. There have been no substantial changes in composition of Cladocera and Copepoda up to 1985 (Johannsson 1987). The effect on Leptodora caused by the changing abundance of alewife has not been studied in Lake Ontario. The main objective of this study was to analyze and estimate the seasonal population parameters of Leptodora kindtii and their interactions with the predominant food web structure and function of the Lake Ontario communities.

LITERATURE REVIEW

The Life Cycle of *Leptodora kindtii*

Leptodora kindtii (Focke) is a planktonic crustacean belonging to the order of Cladocera. This animal is found in many freshwater lakes, ponds and rivers in Europe, North America, and Asia (Wolken and Gallik 1965; Holt et al. 1978). This organism is relatively large, up to 18 mm in length; its body is nearly transparent; it has six pairs of thorasic legs; and has spherical eyes.

In the Great Lakes, *Leptodora kindtii* is commonly found from May through November (Balcer et al. 1984). During the fall season, males and females mate and form resting eggs during the winter months. In the late spring, the eggs hatch as nauplii, molt to metanauplii within a few hours, then molt to 2 mm females in about one day (Cummins et al. 1969). In parthenogenesis, the 1 mm nauplius is released from the brood chamber when the parent molts (Waren 1901). The first parthenogenetically produced females usually mature in June, and continully reproduce throughout the summer (Balcer et al. 1984).

Leptodora was first reported in Germany in 1838 as *Polyphemus kindti* by Focke and Kindt. It was locally described as *Leptodora hyalina* by Lilljeborg (1860) and as

Hyalasoma dux by Wagner (1870). The taxonomic status of this animal was not settled until Sars (1873) and Poppe (1880) agreed to rename this species as *Leptodora kindtii* (Focke) in accordance with the ruling of the 15th International Congress of Zoology in 1964 (Balcer et al. 1984). In North America, Professor S.I. Smith in 1871 and Forbes in 1877 found *Leptodora kindtii* for the first time in Lake Superior and the Illinois river, respectively (Forbes 1886).

Seasonal Changes in Abundance and Distribution of *Leptodora kindtii*

It Is widely known that the abundance and distribution of *L. kindtii* (Focke) is patchy in nature. This animal undergoes major vertical migrations and can avoid plankton traps and small nets (Chandler 1940 ; Andrews 1949 ; Tressler et al. 1953). Sebestyen (1960) studied the food habits and population dynamics of *Leptodora kindtii* in several European lakes. She concluded that there were no satisfactory estimates of the rate of increase of the animal's population or its fluctuation throughout the course of the year. She also pointed out that the population reaches its highest density toward the end of summer or early autumn and maintains this level for couple of months. With low temperature at the end of November and early December, this organism disappears from the plankton community.

Leptodora is a light stimulus or dark-adapted animal (Wolken and Gallik 1965). This behavior and its feeding habits modulate its diurnal migration and distribution in the water column. The distribution of the animal has been broadly studied by Andrews (1949); Mordukhai-Boltovskaia (1958); Hall (1964); Cheremisova (1960); Sebestyen (1960); and Costa and Cummins (1969). The last two were involved not only studying the general pattern of distribution, but also the diurnal vertical migration of the organism in the limnetic water column. They concluded that the pattern of diurnal vertical migration was governed by temperature, light, and oxygen concentration.

Temperature and Oxygen

Moshiri et al. (1969) reported that *Leptodora* occurs in Sanctuary Lake, a portion of Pymatuning Reservoir, when the water temperature exceeds 10 ^{o}C. *Leptodora* did demonstrate a respiratory regulatory plateau over the temperatures range from 15 to 25 ^{o}C (Moshiri et al. 1969). They also believed that temperature was the main factor regulating the abundance of *Leptodora kindtii* in lake systems.

Oxygen consumption of *Leptodora* was the highest for males and the lowest for fecund females (Moshiri et al. 1969). They also identified that the rate of oxygen consumption is essentially constant over the regulatory plateau periods (20 to 25 ^{o}C for females and 15 to 25 ^{o}C for males). However, the respiration rate of Leptodora kindtii is independent of the oxygen concentration at levels above 8 ppm at 22 ^{o}C. Below 8 ppm (90% saturation at 22 ^{o}C) the animals are presumably stressed or abnormally inactive.

Predator-Prey Relationships

Hall (1964) suggested that Leptodora played a significant role in controlling Daphnia mendotae population in Base Line Lake. Wright (1965) also reported that the population of Daphnia schrodleri was severely decreased when Leptodora occured in the Canyon Ferry Reservoir, Montana. Hillbricht-Ilkowska and Karabin (1970) mentioned that the mature Leptodora consumed 15 to 43 % of Cladocera such as Daphnia, Bosmina, and Ceriodaphnia during the summer time. Ceriodaphnia and Bosmina were considered as the most preferable preys (Mordukhai-Boltovskaia 1958; Sebestyen 1960 and Cummins et al. 1969). The later pointed out that there was an inverse relationship between the population densities of Leptodora and Bosmina during their studies in Lake Sanctuary.

In some lakes, Leptodora has an effect on Rotifera (Asplanchna and Euchlanis) and small Copepoda (Mesocyclops) populations (Hall 1964 ; Mordukhai-Boltovskaia 1958). From examination of the gut contents of Leptodora taken from

Sanctuary Lake, Cummins et al. (1969) found unicellular and colonial green algae, ultra phytoplankton, bacteria, fungi, nanno-zooplankton and detrital particles.

On the other hand, Leptodora can be a valuable forage for other aquatic carnivores when they are abundant. It is a part of the diet of large rotifers (Mordukhai-Boltovskaia 1958, 1960) and both larval and adult sicklefish (Pelecus cultratus) during the summer time in European lakes (Sebestyen 1960). In Adirondack lakes (Hutchinson 1972), three Leptodora (average) were found in every stomach of young-of-the-year planktivorous alewives. Leptodora was also found in the gut of gizzard shad, paddlefish, mooneye, wreckfish, and suwannee bass in Illinois River (Forbes 1886). Rainbow trout (Olive 1953), black crappie, white crappie, lake chub, and golden shinner (Costa and Cummins 1972) are known to feed on Leptodora kindtii.

METHODS AND MATERIALS

In 1984, two stations (35 m depth, 43^{o} 21' 44'' latitude and 77^{o} 56' 39'' longitude; 100 m depth, 43^{o} 25' 52'' latitude and 77^{o} 56' 39'' longitude) off Sandy Creek (Figure 1) near the Brockport Water Intake Plant (BWIP) were sampled. Samples were taken biweekly within a three hour period (2300 to 0200) from 17 May to 26 November by Shea (1987). In 1986, samples were also taken biweekly, but in triplicate, within a three hour period from 19 May to 2 December at the two stations of the same depth (10 m) inside and outside the BWIP, weather permitting. In 1987, samples were taken at essentially the same sites (10 m depth inside the BWIP; 100 m depth) and sampling frequency from 25 May to 14 December. The contents of the sampler were washed down into a sampling bucket, transferred into sample bottles and preserved with 10 % formalin. The sampling sites were located with a Loran unit and depth finder.

All samples were collected by Shea (1987) using a single Bongo Net (80 um net mesh, 0.5 m in diameter) equipped with a flow meter (General Oceanic). The sampler was hauled vertically from two meters off the bottom to the surface in 1984 and 1986. In 1987, samples were taken at a depth of 50 m to the surface in 100 m depth of water. Water temperature were determined with a Whitney thermometer or

Bathythermograph. All of the above data collections were taken by Mary Shea and Ted Lewis (our personal communications).

The contents of the preserved samples were transferred and spread evenly (6 - 10 ml sample at a time) into a marked Petri dish for microscopic enumeration. All Leptodora were identified, counted, and measured (body length - Figure 2). The abundance of Leptodora in each sampling date was volumetrically calculated. Rosen (1981) used length-dry weight relationship equation (ln Weight = - 0.822 + 2.670 ln Length) to calculate the dry-weight of Leptodora kindtii. This formula was also used to calculate the population biomass of Leptodora in this study.

RESULTS

Seasonal Population Abundance and Distribution

In 1984, maximum abundance reached 100.9 *Leptodora*/m^3 in late August and 31.6 *Leptodora*/m^3 in early August at the 35 m station and 100 m station, respectively (Figure 3). Average abundance for those periods was 26.5 *Leptodora*/m^3 (35 m) and 9.8 *Leptodora*/m^3 (100 m), respectively (Table 1). In 1986, the maximum abundance reached 6.0 and 239.5 *Leptodora*/m^3 at the same month (mid-August) of both 10 m stations inside and outside the BWIP, respectively (Figure 4). Average abundance (Table 2) for those periods was 2.8 (inside the BWIP) and 31.7 *Leptodora*/m^3 (outside the BWIP). In 1987, the maximum abundance was 175.2 *Leptodoora*/m^3 in the mid-July at the 100 m station while they were not observed at the 10 m (inside the BWIP) station (Figure 5). Average abundance for the 100 m station was 28.7 *Leptodora*/m^3 (Table 3). During those three years periods, abundance was low in the months of June and November (Figures 3, 4, and 5).

Seasonal Population Biomass

In 1984, maximum biomass of *Leptodora* was 32.13 mg/m^3 in late October (35 m) and 5.78 mg/m^3 in mid-June (100 m), respectively (Table 4). Average biomass for those periods was 7.37 mg/m^3 (35 m) and 2.06 mg/m^3 (100 m). In 1986, the maximum biomass was 64.60 mg/m^3 in early October (10 m inside the BWIP) and 40.53 mg/m^3 in late October (10 m outside the BWIP), respectively (Table 5). The average biomass was 28.26 mg/m^3 (10 m inside the BWIP) and 14.68 mg/m^3 (10 m outside the BWIP) in 1986. In 1987, the maximum biomass was 22.78 mg/m^3 in mid-November (100 m) while there were no organisms found at the 10 m (inside the BWIP) station (Table 6). The average biomass for those periods was zero (10 m inside the BWIP) and 7.75 mg/m^3 (100 m).

Male:Female Ratios

During the months of June, July, August, and September of 1984, the females dominated ranging from 52 to 100 % of the population at the 35 m station. At the 100 m station, the male:female ratio was similar to the 35 m station with the exception of October when the females were still at a higher proportion. During the rest of the year, the population is dominated by males (Table 7).

Size Frequency of Population

Construction of size frequency diagrams did not reveal any cohorts throughout the study period (Appendices 1, 2, 3, 4, 5). Seasonal growth curves suggest that the pattern of growth in 1984, 1986, and 1987 was similar (Figures 6, 7, 8). Their general growth pattern were high in spring (late June and early July), then declined in summer, and rebound at maximum peaks in fall.

The general pattern of size class composition of the animal found during the 1984, 1986, and 1987 of sampling dates (Appendices 1, 2, 3, 4, and 5) indicated that the larger individuals (7 to 11.5 mm) were present at low population abundance. The greatest population densities were comprised of smaller individuals [3 to 4 mm (35 m, 100 m; 1984), 2 to 3 mm (10 m; 1986), and 5 to 6 mm (100 m; 1987)].

DISCUSSION

Male:Female Ratios

Females appear to comprise 100 % of the total population in late June up to early August (Table 7). The males appeared for the first time in mid-August and gradually increased in time, dominating the population until both sexes totally disappeared from plankton community in late November. During the summer season, there was higher percentage of females than males present. This is related to a part of reproduction cycle (parthenogenesis) of Leptodora which mostly involves the role of females in its population. At the end of the parthenogenetic phase cycle (late summer), the males were produced and involved in the Leptodora's sexual reproduction until early December. This pattern of reproduction cycle governs the proportion of males and females in Leptodora's population structure in Lake Ontario. This result agrees with the study of Sebestyen (1960) in Lake Balaton and Cummins et al. (1969) in Lake Sanctuary.

Cummins et al. (1969) believed that smaller immature females (2-5 mm) were less predatory but more active and larger mature females (6-12 mm) were predatory but less active in their migration behavior. They also identified that all mature males were predatory and more active in its migration.

Population Number Per Size Class Composition

Leptodora kindtii has a long reproductive period, relative to its lifespan. Multivoltine organisms, such as *Leptodora*, may not have clearly separable cohorts, and individuals from one cohort may be of many sizes (Rigler and Downing 1984).

In Lake Ontario, population growth of *Leptodora* were similar in each of the study years (Figures 6, 7, 8). A comparison of population growth and seasonal size class composition of *Leptodora* in Lake Sanctuary (Cummins et al. 1969) to the present study (Appendices 1, 2, 3, 4, and 5), showed some similarities. It also identified that the periods of high abundance were comprised of larger size classes in Sanctuary Lake (ranging from 4.0 to 8.0 mm) than the present study (ranging from 2.0 to 6.0 mm). Stein et al. (1988) pointed out that the growth rates and susceptibility of zooplankton to predators vary with the size of the organism and the food-web interactions depend strongly on the body size. It implies that the intense occurrence of smaller size/age structured swarms of *Leptodora* in the open pelagial may be impacted by planktivore predation.

Seasonal Population Biomass

Mills and Forney (1988) believe that community structure, biomass, and production of zooplankton in the pelagic food webs of lakes are influenced by both producer and consumer forces and the maximum attainable biomass is set by the lake productivity. During the study period, seasonal population biomass was similar in each of the study years (Tables 4, 5, 6). Biomass reached the highest peaks during October and November (Figures 16, 17, 18), when adults (all males) were at their largest size.

In Lake Sanctuary, Pennsylvania, the average annual population biomass of _Leptodora kindtii_ was estimated at 32.53 milligram/m^3 in 1966 and 89.60 milligram/m^3 in 1967. These values are higher by 83.6 to 97.7 % (annual average) than the biomass found in Lake Ontario during this study period (annual average ranging from 2.06 to 14.68 mg/m^3; Table 9).

Temperature as an Influence on Seasonal Abundance

Environmental factors that might affect abundance, distribution, and production of zooplankton are temperature, food availability, character of habitat or substrate, and oxygen sufficiency (Rigler and Downing 1984). As the function of temperature, the individual growth of _Leptodora_ showed unequal developmental rates from their first appearance as embryos in the brood sac and as a free swimming young animals (Mordukhai-Boltovskaia 1958; Cummins et al. 1969). In general, the pattern of seasonal abundance and distribution of Leptodora kindtii in Lake Ontario is similar between each year. Two maximum peaks appear each year in late summer (Figures 3, 4, and 5). When the average temperature is the highest (Figure 9; Appendices 6, 7) and the epilimnion proportionally reached its maximum depth (Figures 10, 11), the abundance of Leptodora reaches its maximum population. During the study period (Figures 12, 13, 14, 15), temperature correlates positively with seasonal abundance of Leptodora in Lake Ontario [coefficient determination (r^2) ranging from 0.29 to 0.67]. The positive association of temperature and abundance of Leptodora in Lake Ontario has been observed before by Patalas (1969).

Nearshore Versus Offshore Abundance

Zooplankton community structure varies as a function of distance from shore or station depth, and this gradient is especially sharp during the summer when the inshore region serves as a nursery area for several planktivorous fishes (Evans 1986). In Lake Ontario, the predominant factors that govern the horizontal distribution of zooplankter Leptodora were temperature, morphometry of the basin, exposure to wind, location of influents and effluents, and the chemistry of the water masses (Patalas 1969).

With the exception of mid June and September and early November, the mean seasonal abundance of Leptodora was higher by 74.6 % at the nearshore (35 m) station than the offshore (100 m) station in 1984 (Table 1). A greater abundance of the nearshore vs. offshore was also identified by Czaika (1974). The nearshore waters, with more nutrients available and an higher temperatures earlier in the season than the offshore, tends to support a larger Leptodora abundance at the nearshore than the offshore of Lake Ontario. This situation may lead to more intense predation of Leptodora upon the other smaller zooplankton (e.g Daphnia, Bosmina, Ceriodaphnia) in the nearshore than the offshore areas.

Historical Comparison of Abundance

Seasonal abundance of Leptodora in Lake Ontario has been variable between years (Table 8). Despite slight differences in sampling time and sampler mesh size applied (Table 9), the 1972 observations on maximum and annual abundances of Leptodora at a different sampling depths on the south side of Lake Ontario (Czaika 1974) can be compared to the maximum and the annual values of the present study. The maximum abundance (35.0 Leptodora/m^3) for Czaika's 13-40 m station was lower by 51.2 % to this study (71.7 Leptodora/m^3 at 35 m), but was higher by 18.5 % for the annual abundance (Table 8). The maximum abundance (32.0 *Leptodora*/m^3) for Czaika's 44-129 m station was higher by 10.6 % to this study (28.6 *Leptodora*/m^3 at 100 m; 1984) but was lower by 63.9 % for the same station in 1987. The annual abundance (16.0 *Leptodora*/m^3) for Czaika's 44-129 m station, was higher by 54.4 % to this study (7.3 *Leptodora*/m^3 at 100 m, 1986) but was lower by 37.5 % for the same station in 1987. During the study period, the maximum and the annual abundances of the 1984 (28.6 and 7.3 *Leptodora*/m^3, 100 m) was lower by 67.9 % and 71.5 % to the 1987 (88.8 and 25.6 *Leptodora*/m^3, 100 m), respectively (Table 8). Fluctuations in abundance of *Leptodora* in 1972 and during the study period may be related to planktivorous fish (e.g. alewife) predation, if the attainable *Leptodora*'s abundance was set by the consumer rather than the producer forces or/and the abiotic factors of Lake Ontario.

Annual Trends and Overview on Abundance of Leptodora in the Predominant Food Web Structure Interactions of Lake Ontario

In Lake Ontario, alewife (*Alosa pseudoharengus*) was first recognized abundantly in the spring of 1873 (O'Gorman and Schneider 1986) and remains the predominant planktivore in the food web structure to the present day. Information on its biology and population fluctuation is scant and limited (O'Gorman and Schneider 1986). In Lake Ontario, from 1978 to 1987, weather condition (severe winter) and salmonines predation were identified as factors causing the variability in alewife abundance (O'Gorman and Schneider 1986; O'Gorman 1987).

Planktivorous alewife was identified as the cause of the nearly complete disappearance of Leptodora population in several Adirondack lakes (Hutchinson 1972), Lake Michigan (Wells 1970) and Connecticut lakes (Brooks and Dodson 1965; Warshaw 1972).

In Lake Ontario, the abundance of Leptodora fluctuated seasonally and annually in each of the study years (Table 8). The annual abundance of Leptodora versus the annual abundance of alewife does reveal a positive, but insignificant correlation (Figure 19). My results suggest that alewife do not affect Leptodora abundance, which is contratry to many other studies (Brooks and Dodson 1965; Wells 1970; Hutchinson 1972).

The insignificance of alewife's predation upon Leptodora in Lake Ontario may have been caused by several factors. First, it can be caused by the biasses from the heterogeneity of data sources between the two variables (the mean annual abundance of Leptodora versus the single spring abundance of alewife and the differences in spatial and temporal scales). O'Gorman (1987) used the single spring (April-June) data sampling to represent the annual abundance of alewife. Second, it could be caused by the buffering capacity provided by other larger-sized preys such as Mysis, Pontoporeia, and

Gammarus (Shea 1987; Iancu 1987) which alewife more readily feed on. Thirdly, it can be caused by the unique transparency of the Leptodora's body. This is the must likely cause.

In fact, the several years of Leptodora's abundance in the spring time varied in lowest numbers from 0.0 to 2.0 Leptodora/m^3, compared to the other seasons (Table 8). In non alewife planktivore Sanctuary Lake (Cummins et al. 1969), the abundance of plankters during the spring time (May-June) of 1966-1967 period varied in highest numbers from 153.3 to 1066.4 Leptodora/m^3, compared to the present study (Table 8). The comparison of these two lakes spring data may reveal the influence of alewife predation upon Leptodora in alewife planktivore lakes. The lowest numbers of Leptodora occur in the spring when the highest recruitment of alewife population occurs (O'Gorman and Schneider 1986) due to yearling production.

Planktivory clearly can alter zooplankton community structure of lakes (Carpenter 1988). However, more representative data base for alewife and Leptodora are needed in Lake Ontario to evaluate planktivory. Homogeneity in spatial and temporal scales of the long term data collection will help to meet this goal and should clarify the food web structure interactions between these two organisms in Lake Ontario and other lakes.

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Table 1. Population abundance ($\#/m^3$) of <u>Leptodora kindtii</u> at the 35 m and 100 m stations in 1984.

Sampling Date	35 m station ($\#/m^3$)	100 m station ($\#/m^3$)
17-MAY-1984	0.0	0.0
05-JUN-1984	0.0	0.0
19-JUN-1984	0.4	0.6
06-JUL-1984	5.1	0.0
20-JUL-1984	25.3	1.4
03-AUG-1984	74.5	31.6
15-AUG-1984	39.6	-
29-AUG-1984	100.9	25.6
12-SEP-1984	20.4	21.1
24-SEP-1984	14.3	4.8
08-OCT-1984	4.7	1.6
23-OCT-1984	6.3	0.7
07-NOV-1984	0.1	0.4
26-NOV-1984	0.0	0.0
Mean	26.5	9.8

Table 2. Population abundance ($\#/m^3$) of *Leptodora kindtii* at the 10 m (BWIP) and 10 m stations in 1986. BWIP = inside the Brockport Water Intake Plant.

Sampling Date	10 m (BWIP) station 1	2	3	Average ($\#/m^3$)	10 m station 1	2	3	Average ($\#/m^3$)
19-MAY-1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
02-JUN-1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16-JUN-1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30-JUN-1986	0.0	0.0	0.0	0.0	1.9	3.4	3.6	3.0
14-JUL-1986	0.0	0.0	0.0	0.0	0.0	0.7	0.6	0.4
28-JUL-1986	0.0	0.0	0.0	0.0	4.7	9.6	10.6	8.3
11-AUG-1986	0.0	6.0	12.0	6.0	428.9	175.3	114.4	239.5
25-AUG-1986	6.0	0.0	0.0	2.0	15.6	19.7	-	17.7
08-SEP-1986	0.0	6.0	0.0	2.0	58.4	101.3	43.0	67.6
22-SEP-1986	0.0	0.0	0.0	0.0	2.1	0.6	0.7	1.1
07-OCT-1986	0.0	2.0	2.0	1.3	4.8	3.4	5.7	4.6
20-OCT-1986	0.0	0.0	0.0	0.0	0.5	4.1	0.6	1.7
03-NOV-1986	0.0	0.0	0.0	0.0	9.3	4.4	1.1	4.9
17-NOV-1986	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.2
02-DEC-1986	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean				2.8				31.7

Table 3. Population abundance ($\#/m^3$) of <u>Leptodora kindtii</u> at the 10 m (BWIP) and 100 m stations in 1987. BWIP = inside the Brockport Water Intake Plant.

Sampling Date	10 m (BWIP) station 1	2	3	Average ($\#/m^3$)	100 m station 1	2	3	Average ($\#/m^3$)
25-MAY-1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10-JUN-1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22-JUN-1987	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1
06-JUL-1987	0.0	0.0	0.0	0.0	2.2	2.5	2.1	2.3
20-JUL-1987	0.0	0.0	0.0	0.0	189.6	168.4	167.5	175.2
04-AUG-1987	0.0	0.0	0.0	0.0	9.3	3.5	8.6	7.1
17-AUG-1987	0.0	0.0	0.0	0.0	56.0	49.6	110.3	72.0
02-SEP-1987	0.0	0.0	0.0	0.0	14.3	18.6	29.0	20.6
14-SEP-1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28-SEP-1987	0.0	0.0	0.0	0.0	4.7	6.5	4.1	5.1
12-OCT-1987	0.0	0.0	0.0	0.0	10.1	24.5	22.9	19.2
26-OCT-1987	0.0	0.0	0.0	0.0	15.6	10.0	8.7	11.4
16-NOV-1987	0.0	0.0	0.0	0.0	0.7	0.9	0.4	0.7
30-NOV-1987	0.0	0.0	0.0	0.0	0.8	1.3	2.0	1.4
14-DEC-1987	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean				0.0				28.7

Table 4. Seasonal biomass of *Leptodora kindtii* calculated at the 35 m and 100 m stations in 1984.

Sampling Date	35 m station Biomass (mg/m^3)	100 m station Biomass (mg/m^3)
17-MAY-1984	0.00	0.00
05-JUN-1984	0.00	0.00
19-JUN-1984	7.65	5.78
06-JUL-1984	11.25	0.00
20-JUL-1984	1.84	1.00
03-AUG-1984	5.47	2.50
15-AUG-1984	1.05	-
29-AUG-1984	2.24	0.60
12-SEP-1984	5.78	0.62
24-SEP-1984	4.10	1.12
08-OCT-1984	5.69	2.64
23-OCT-1984	32.13	1.78
07-NOV-1984	3.90	2.49
26-NOV-1984	0.00	0.00
Mean	7.37	2.06

Table 5. Seasonal biomass of <u>Leptodora kindtii</u> calculated at the 10 m (BWIP) and 10 m stations in 1986. BWIP = inside the Brockport Water Intake Plant.

Sampling Date	10 m (BWIP) station Biomass (mg/m^3)	10 m station Biomass (mg/m^3)
19-MAY-1986	0.00	0.00
02-JUN-1986	0.00	0.00
16-JUN-1986	0.00	0.00
30-JUN-1986	0.00	22.00
14-JUL-1986	0.00	1.34
28-JUL-1986	0.00	5.73
11-AUG-1986	29.34	1.67
25-AUG-1986	12.10	3.89
08-SEP-1986	6.98	4.06
22-SEP-1986	0.00	16.72
07-OCT-1986	64.60	8.93
20-OCT-1986	0.00	40.53
03-NOV-1986	0.00	31.98
17-NOV-1986	0.00	24.66
02-DEC-1986	0.00	0.00
Mean	28.26	14.68

Table 6. Seasonal biomass of *Leptodora kindtii* calculated at the 10 m (BWIP) and 100 m stations in 1987. BWIP = inside the Brockport Water Intake Plant.

Sampling Date	10 m (BWIP) station Biomass (mg/m^3)	100 m station Biomass (mg/m^3)
25-MAY-1987	0.00	0.00
10-JUN-1987	0.00	0.00
22-JUN-1987	0.00	3.12
06-JUL-1987	0.00	2.73
20-JUL-1987	0.00	4.20
04-AUG-1987	0.00	2.28
17-AUG-1987	0.00	1.37
02-SEP-1987	0.00	1.40
14-SEP-1987	0.00	0.00
28-SEP-1987	0.00	3.30
12-OCT-1987	0.00	2.42
26-OCT-1987	0.00	21.30
16-NOV-1987	0.00	22.78
30-NOV-1987	0.00	20.36
14-DEC-1987	0.00	0.00
Mean	0.00	7.75

Table 7. Percent male and female adult *Leptodora kindtii* at the 35 m and 100 m stations in 1984.

Sampling Date	35 m station			100 m station		
	Total (#)	Male (%)	Female (%)	Total (#)	Male (%)	Female (%)
17-MAY-1984	0.0	0.0	0.0	0.0	0.0	0.0
05-JUN-1984	0.0	0.0	0.0	0.0	0.0	0.0
19-JUN-1984	1.0	0.0	100.0	2.0	0.0	100.0
06-JUL-1984	14.0	7.2	92.8	0.0	0.0	0.0
20-JUL-1984	228.0	0.0	100.0	17.0	0.0	100.0
03-AUG-1984	278.0	0.0	100.0	174.0	0.0	100.0
15-AUG-1984	583.0	8.3	91.7	-	-	-
29-AUG-1984	666.0	3.0	97.0	449.0	1.6	98.6
12-SEP-1984	85.0	20.0	80.0	512.0	18.4	81.6
24-SEP-1984	80.0	48.0	52.0	91.0	36.3	63.7
08-OCT-1984	31.0	67.8	32.2	28.0	46.4	53.6
23-OCT-1984	11.0	54.6	45.4	17.0	47.1	52.9
07-NOV-1984	1.0	100.0	0.0	8.0	87.5	12.5
26-NOV-1984	0.0	0.0	0.0	0.0	0.0	0.0

Table 8. Comparison of seasonal abundance (#/m^3) of <u>Leptodora kindtii</u> in 1970, 1972, 1981, 1982, 1984, 1986, and 1987, Lake Ontario. Values are the average in each month.

SAMPLING TIMES	Watson & Carpenter		Czaika		Johannsson et al.		Present study			
	1970		1972		1981	1982	1984		1986	1987
	(0-225) m	(5-6) m	(13-40) m	(44-129) m	(17-128) m	(17-128) m	35 m	100 m	10 m	100 m
MAY	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
JUNE	0.0	0.0	0.0	0.0	0.0	2.0	0.2	0.3	1.0	0.1
JULY	3.3	18.0	0.0	0.0	15.0	0.0	15.2	0.7	4.4	88.8
AUGUST	98.0	30.0	0.0	4.0	29.4	14.0	71.7	28.6	128.6	39.6
SEPTEMBER	58.0	108.0	35.0	32.0	23.5	10.0	17.4	13.0	34.4	8.6
OCTOBER	8.4	0.0	8.0	12.0	0.0	7.0	5.5	1.2	3.2	15.3
NOVEMBER	0.0	0.0	2.0	0.0	0.0	0.0	0.1	0.2	2.6	1.1
DECEMBER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean	41.9	52.0	15.0	16.0	22.6	10.3	18.4	7.3	29.0	25.6

Table 9. Comparison of mean abundance and biomass of <u>Leptodora kindtii</u> (Focke) between Lake Ontario and Lake Sanctuary.

DESCRI BTI ON	AUTHORS AND DATE PUBLICATION: Cummins et al. (1969)	Watson & Carpenter (1974)	Czaika (1974)	Johannsson et al. (1985)	Present study (1989)
Lake	Sanctuary	Ontario	Ontario	Ontario	Ontario
Sampling Gear	Plankton Net	Plankton Net	Plankton Net	Plankton Net	Single Bongo Net
Type of Hauling	Horizontal	Vertical	Vertical	Vertical	Vertical
Mouth Diameter	0.3 m	0.4 m	0.5 m	0.3 m	0.5 m
Mesh Size of Net	1.024 mm	64 u	64 u	70 u	80 u
Sampling Time	Night	Day/Night	Day	Day	Night
Number of Station	4	33	21	4	5
Station Depth (m)	2-3	0-225	5-129	17-128	10-100

Sampling Year	1966	1967	1970	1972	1981	1982	1984	1986	1987
Mean Abundance	$247.3/m^3$ at 2-3m	$652.9/m^3$ at 2-3m	$41.9/m^3$ at 0-225m	$52.0/m^3$ at 5-6m $15.0/m^3$ at 13-40m $16.0/m^3$ at 44-129m	$22.6/m^3$ at 17-128m	$10.3/m^3$ at 17-128m	$18.4/m^3$ at 35m $7.3/m^3$ at 100m	$29.0/m^3$ at 10m	$25.6/m^3$ at 100m
Mean Biomass	32.53 mg/m^3 at 2-3m	89.60 mg/m^3 at 2-3m					7.37mg/m^3 at 35m 2.06mg/m^3 at 100m	14.68mg/m^3 at 10m	7.75mg/m^3 at 100m

Table 10. Annual trends of alewife and *Leptodora* abundance in Lake Ontario.

Year Sampling	Adult Alewife (X 10^6)	Source & Year Publication	Leptodora (#/m^3)	Source & Year Publication
1981	3,850	O'Gorman & Schneider (1986)	22.6	Johannsson et al. (1985)
1982	3,545	O'Gorman & Schneider (1986)	10.3	Johannsson et al. (1985)
1984	1,950	O'Gorman (1987)	7.3	Present study
1986	5,100	O'Gorman (1987)	29.0	Present study
1987	1,780	O'Gorman (1987)	25.0	Present study

Figure 1. Lake Ontario Sampling Station Site Map

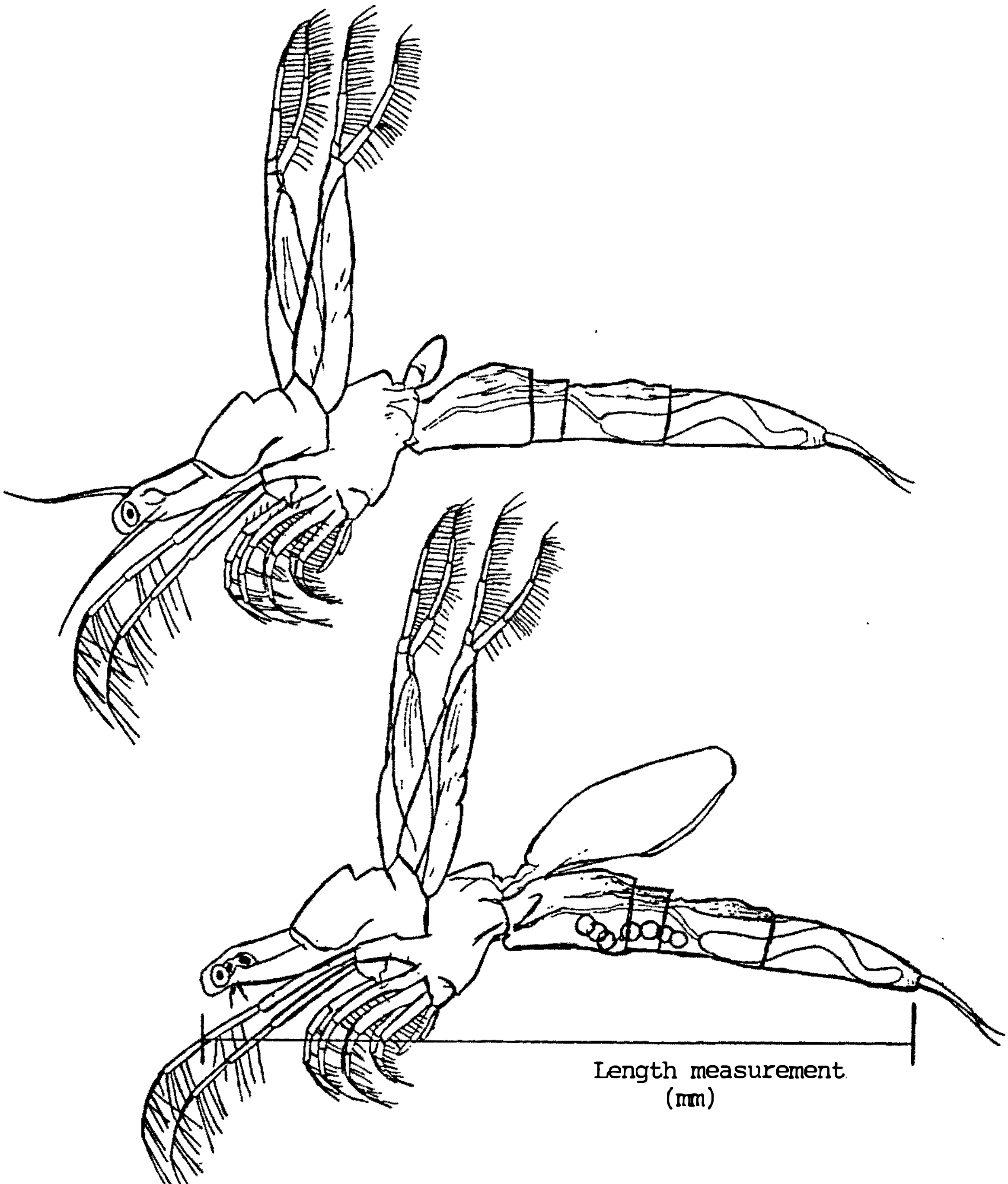


Figure 2. Lateral view of adult male and female
Leptodora kindtii (Focke).

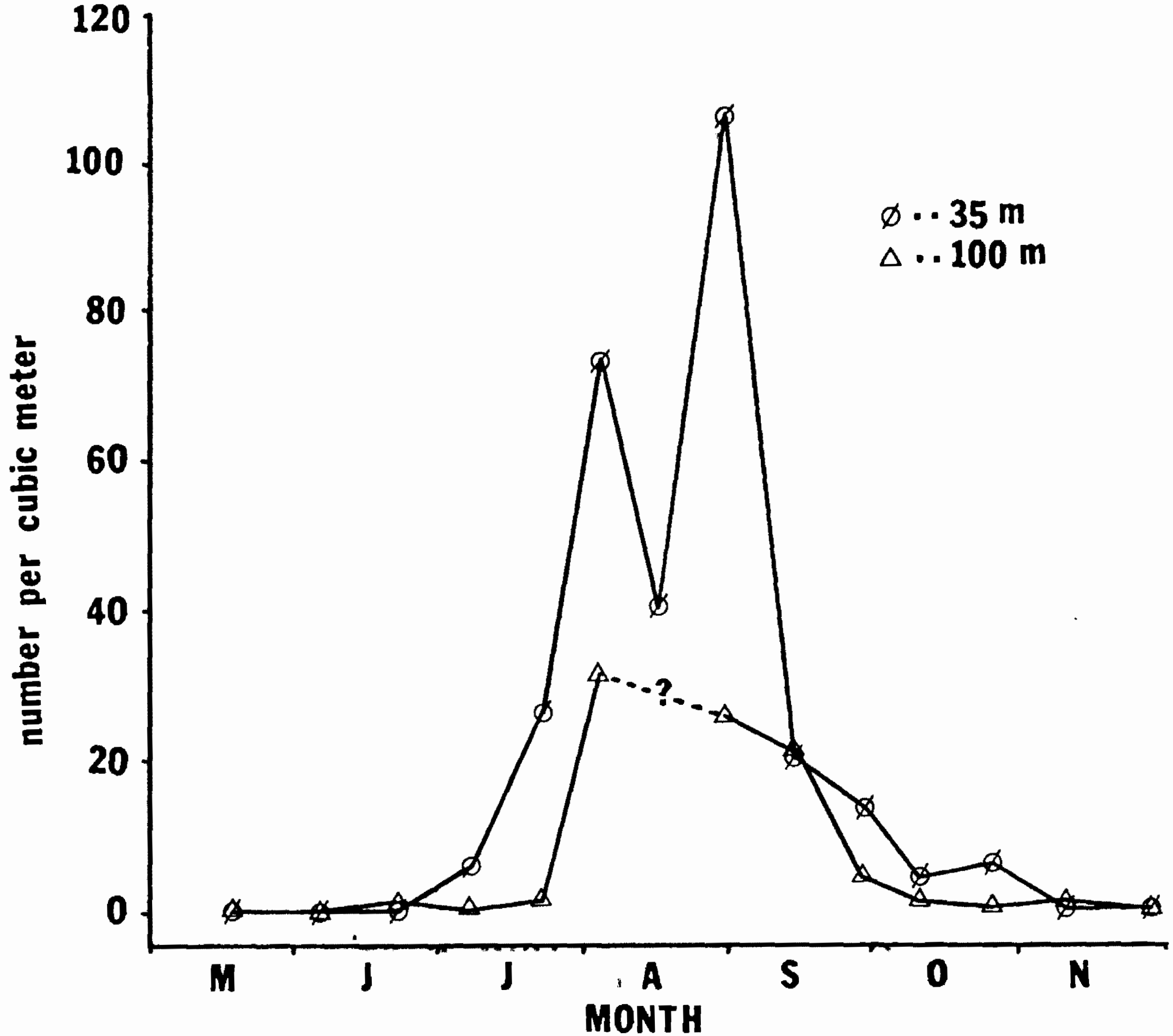


Figure 3. Population abundance of Leptodora kindtii at the 35 m and 100 m stations in 1984.

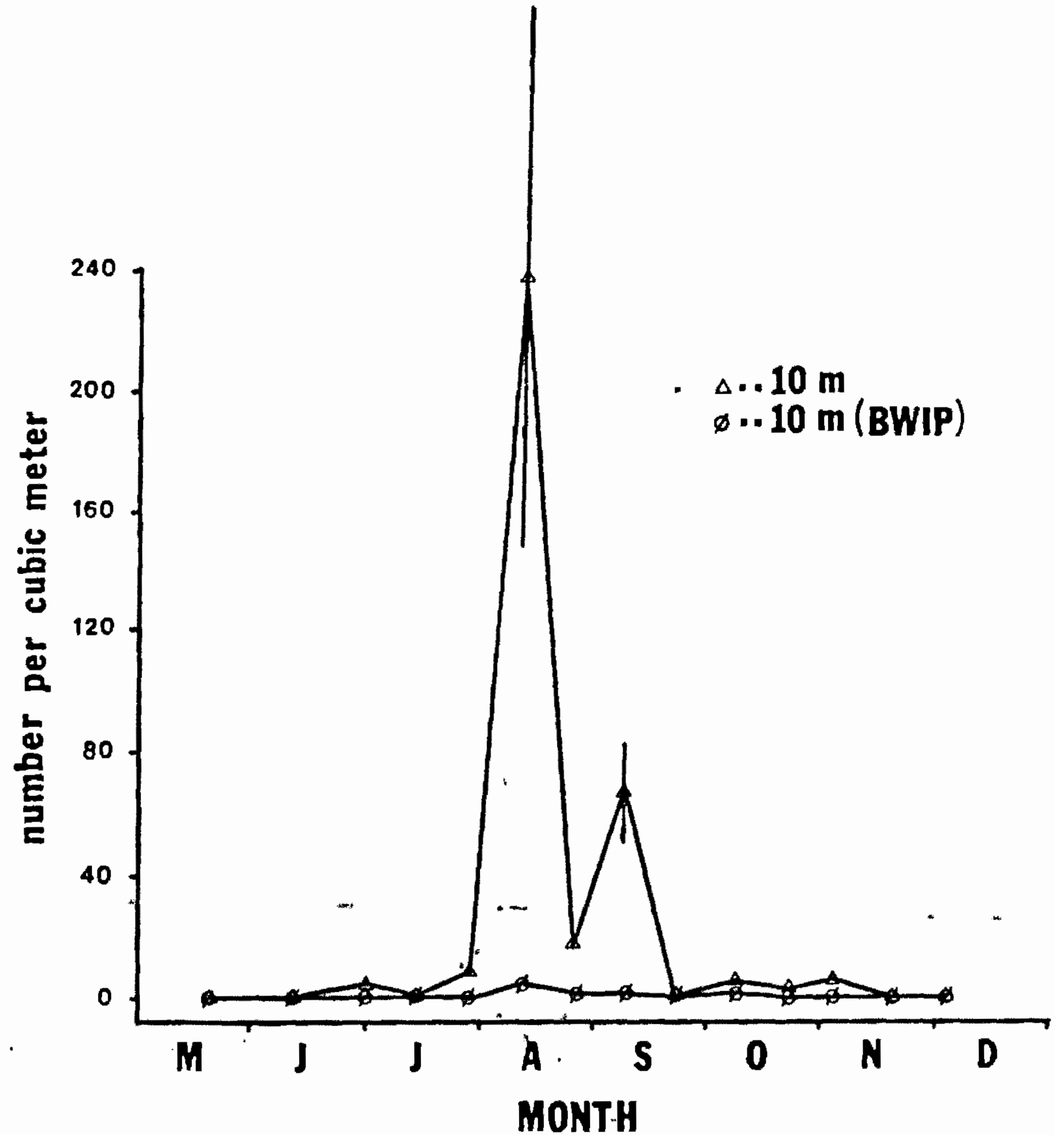


Figure 4. Population abundance of Leptodora kindtii at the 10 m (BWIP) and 10 m stations in 1986. Values are the mean ± standard error.

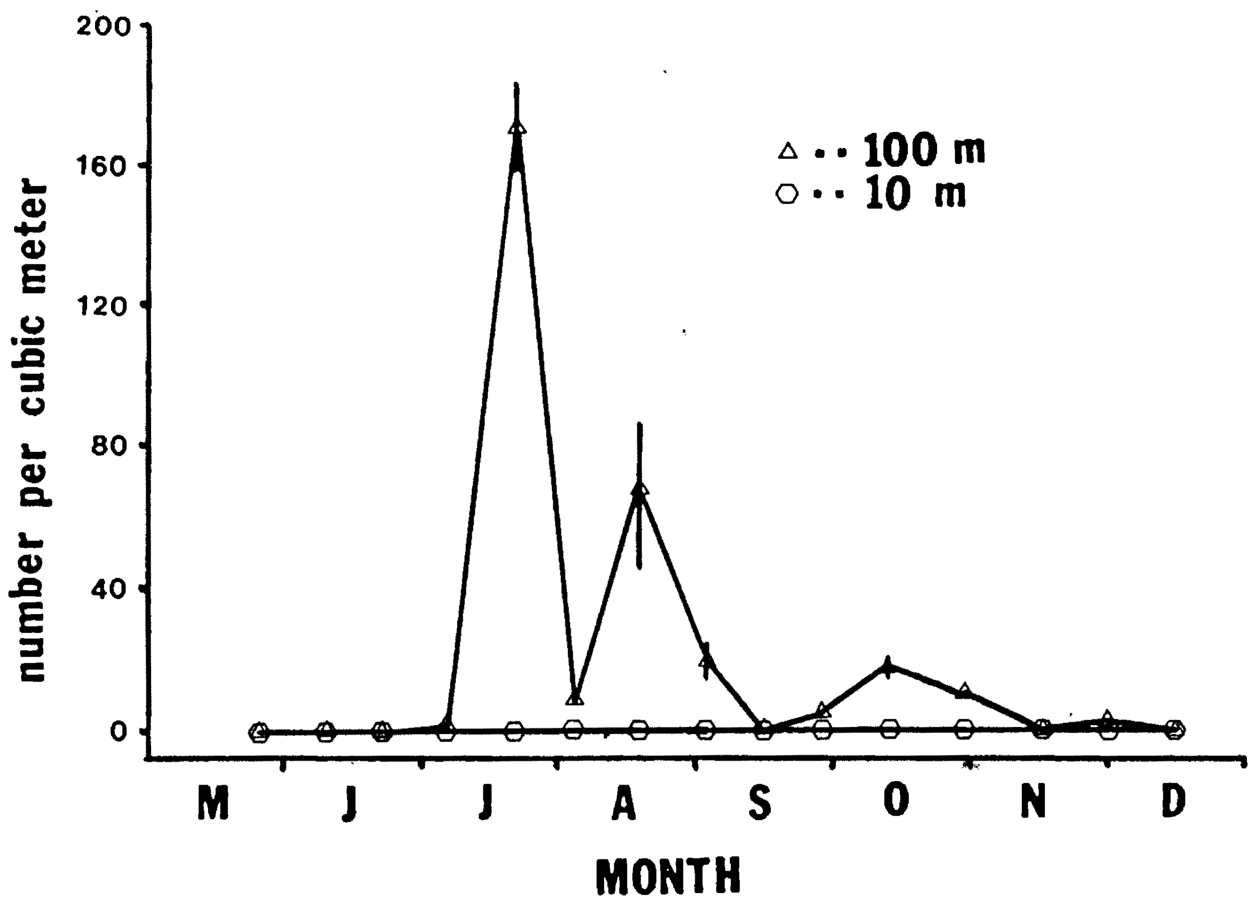


Figure 5. Population abundance of Leptodora kindtii at the 10 m (BWIP) and 100 m stations in 1987. Values are the mean ± standard error.

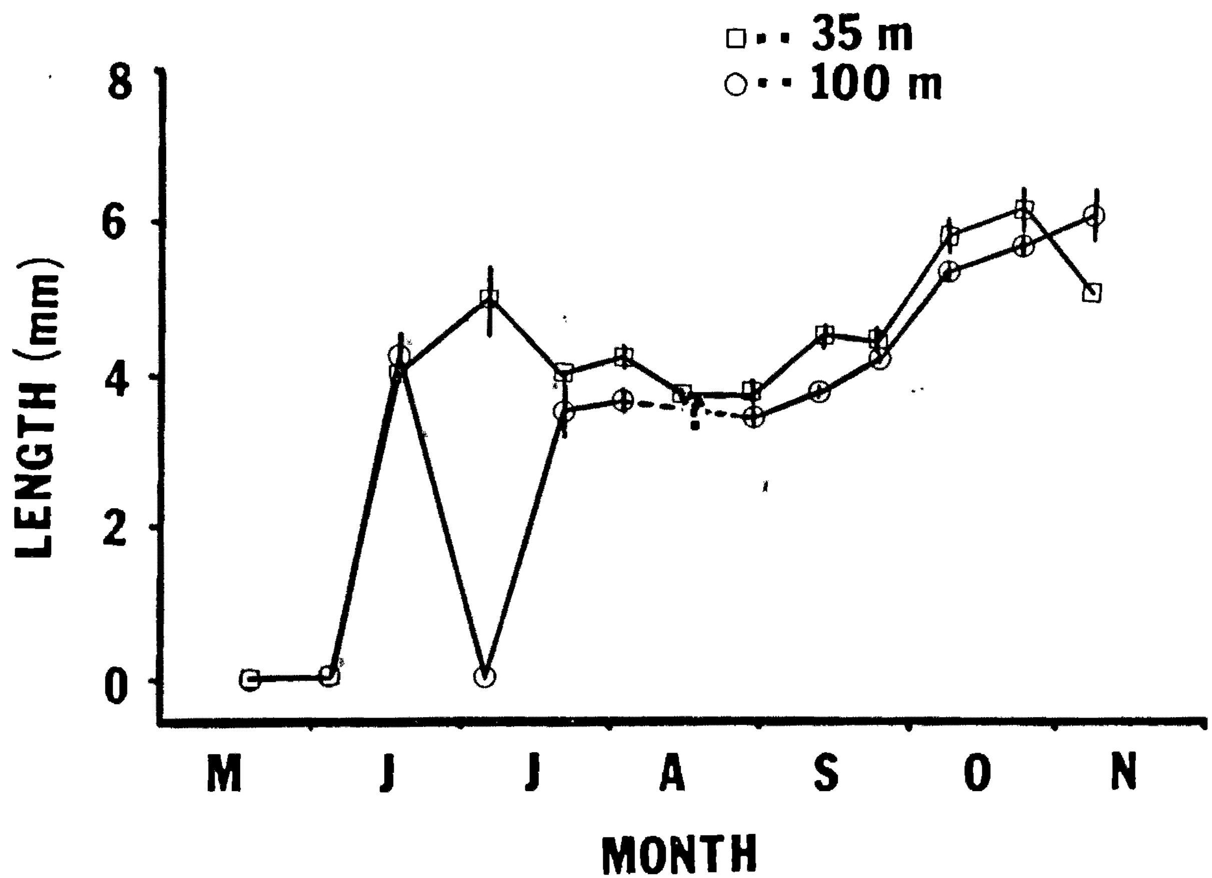


Figure 6. Seasonal growth of Leptodora kindtii at the 35 m and 100 m stations in 1984. Values are the mean ± standard error.

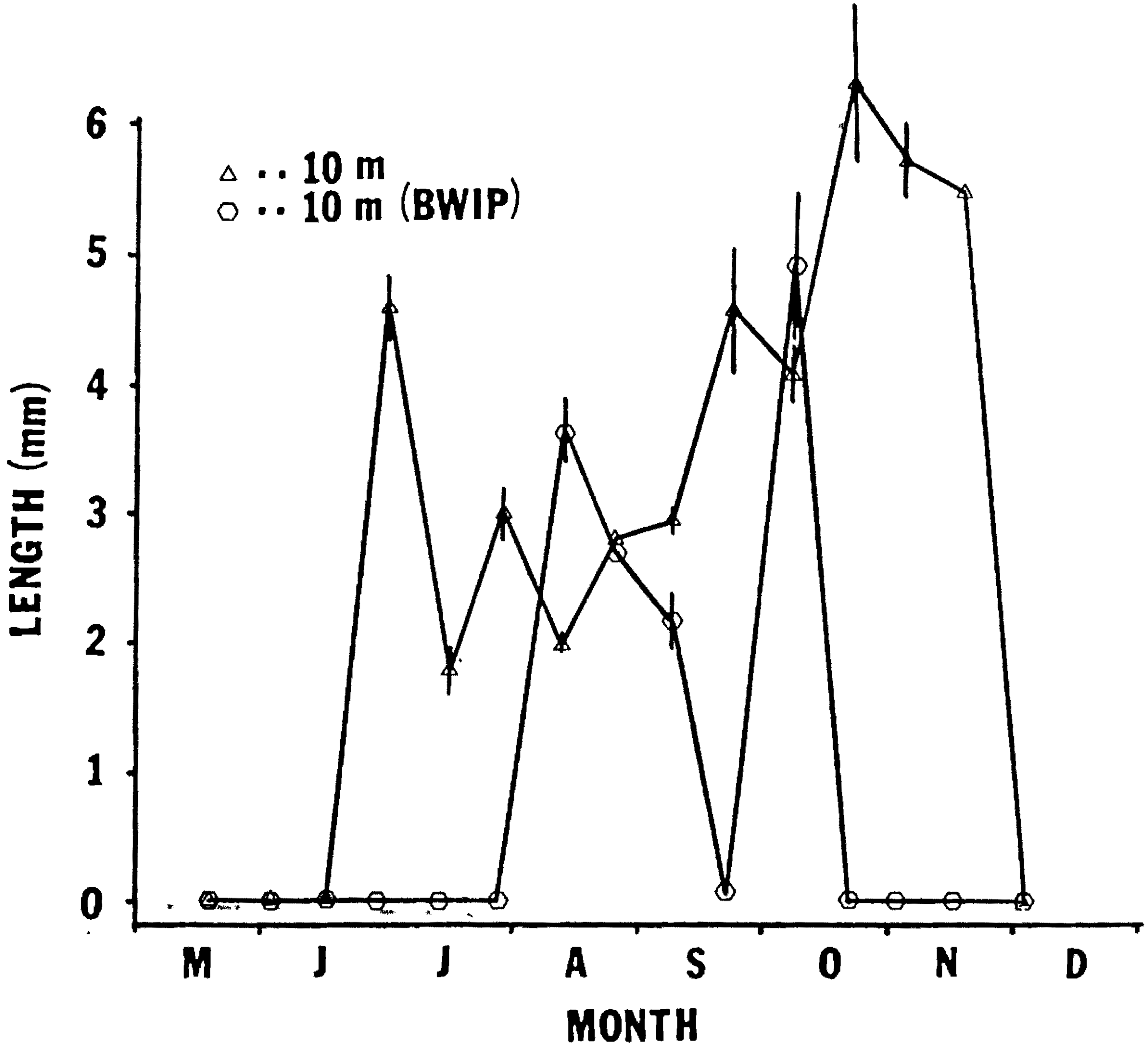


Figure 7. Seasonal growth of <u>Leptodora kindtii</u> at the 10 m (BWIP) and 10 m stations in 1986. Values are the mean ± standard error.

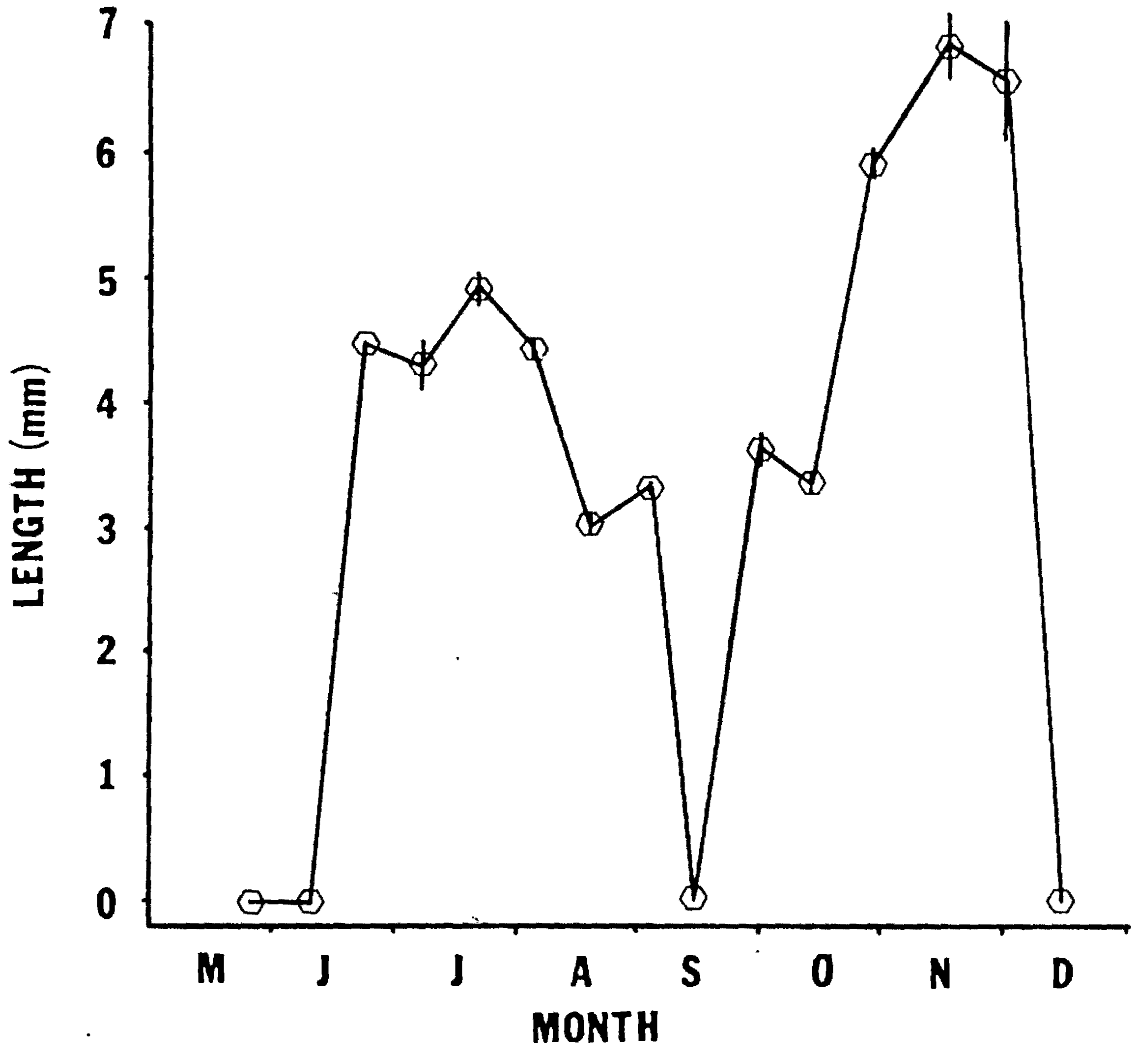


Figure 8. Seasonal growth of Leptodora kindtii at the 100 m station in 1987. Values are the mean ± standard error.

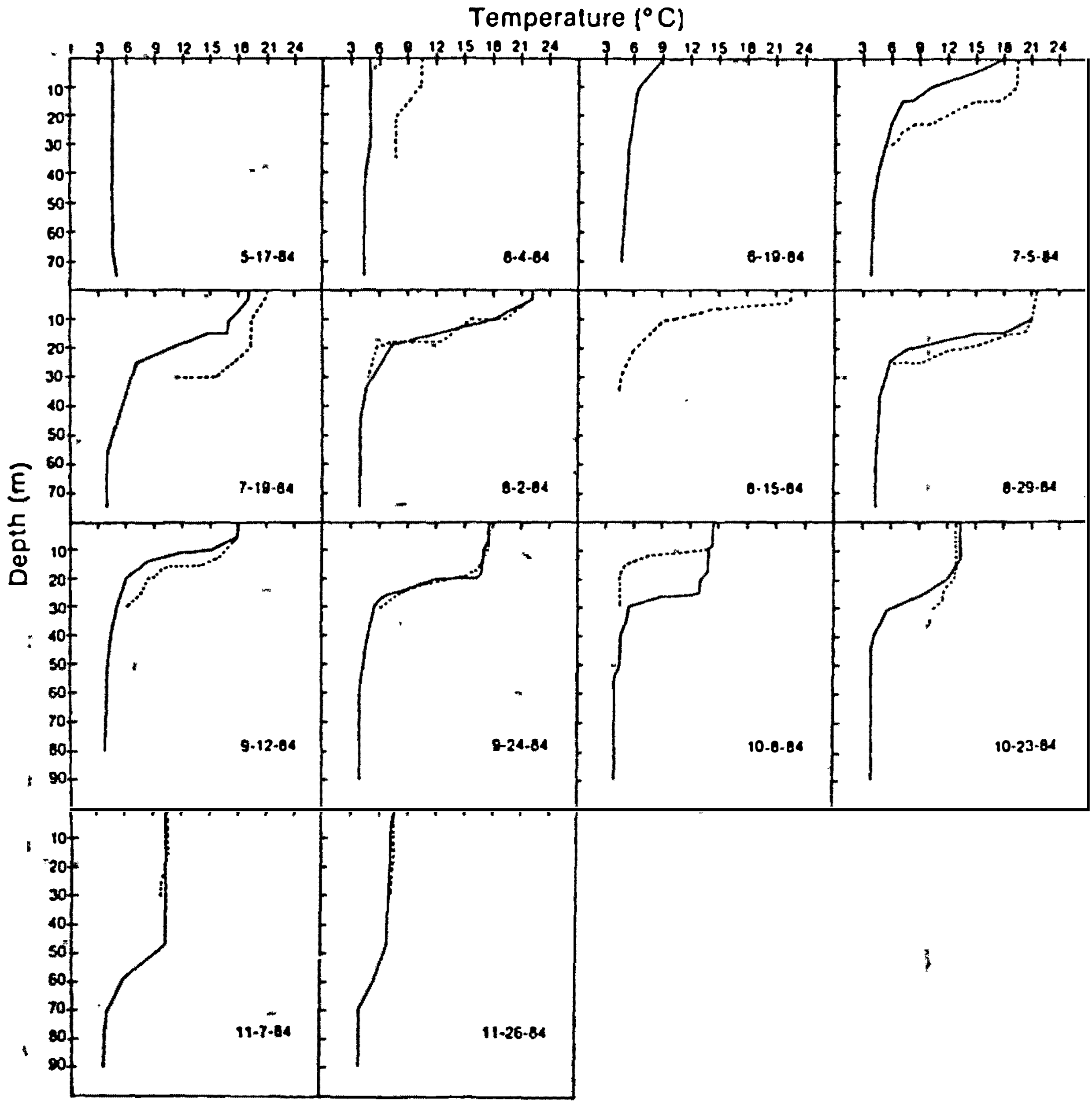


Figure 9. Temperature profile at the 35 m and 100 m stations in 1984. (Reproduced from Shea, 1987).

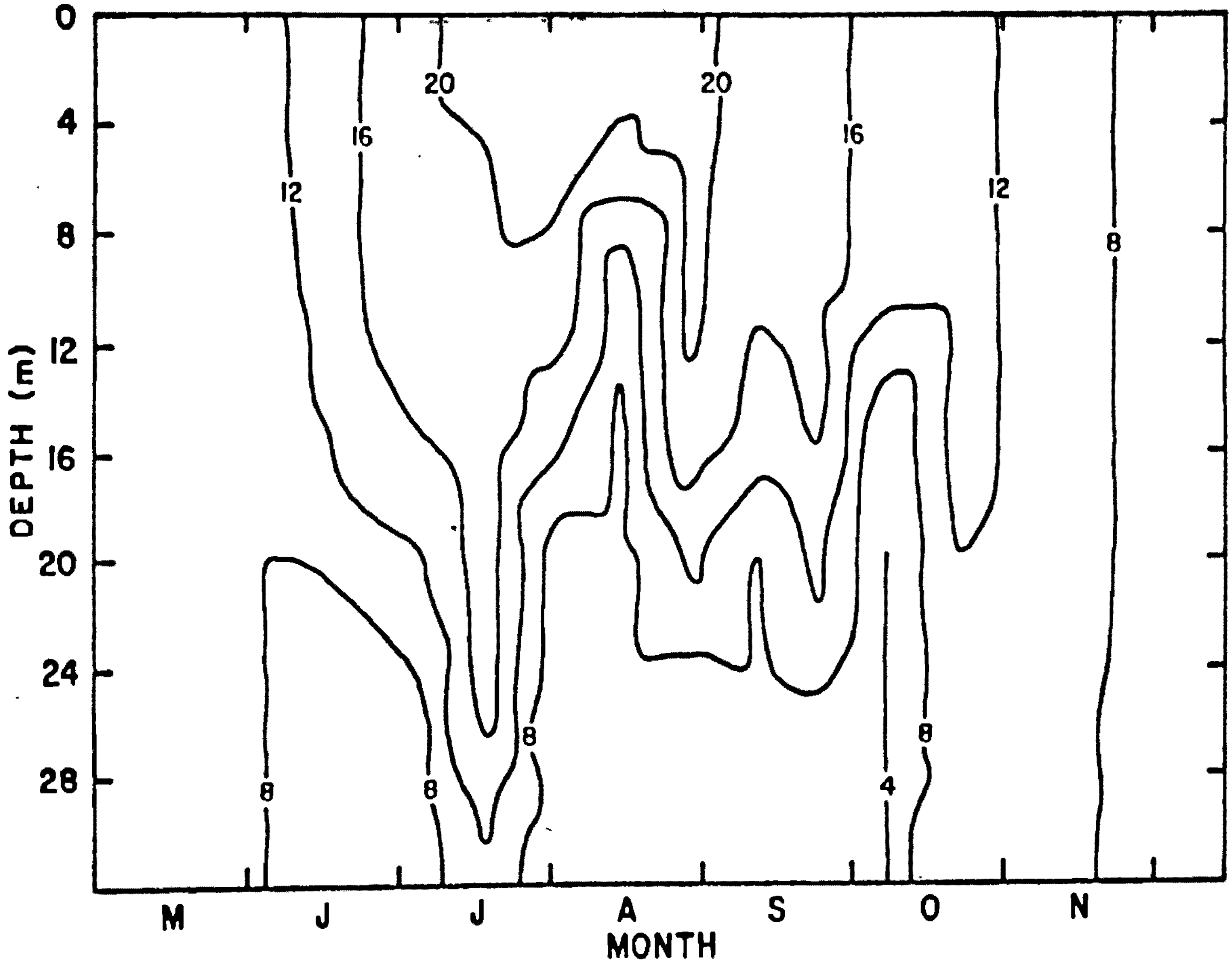


Figure 10. Thermal structure of the 35 m station in 1984 (reproduced from Shea 1987).

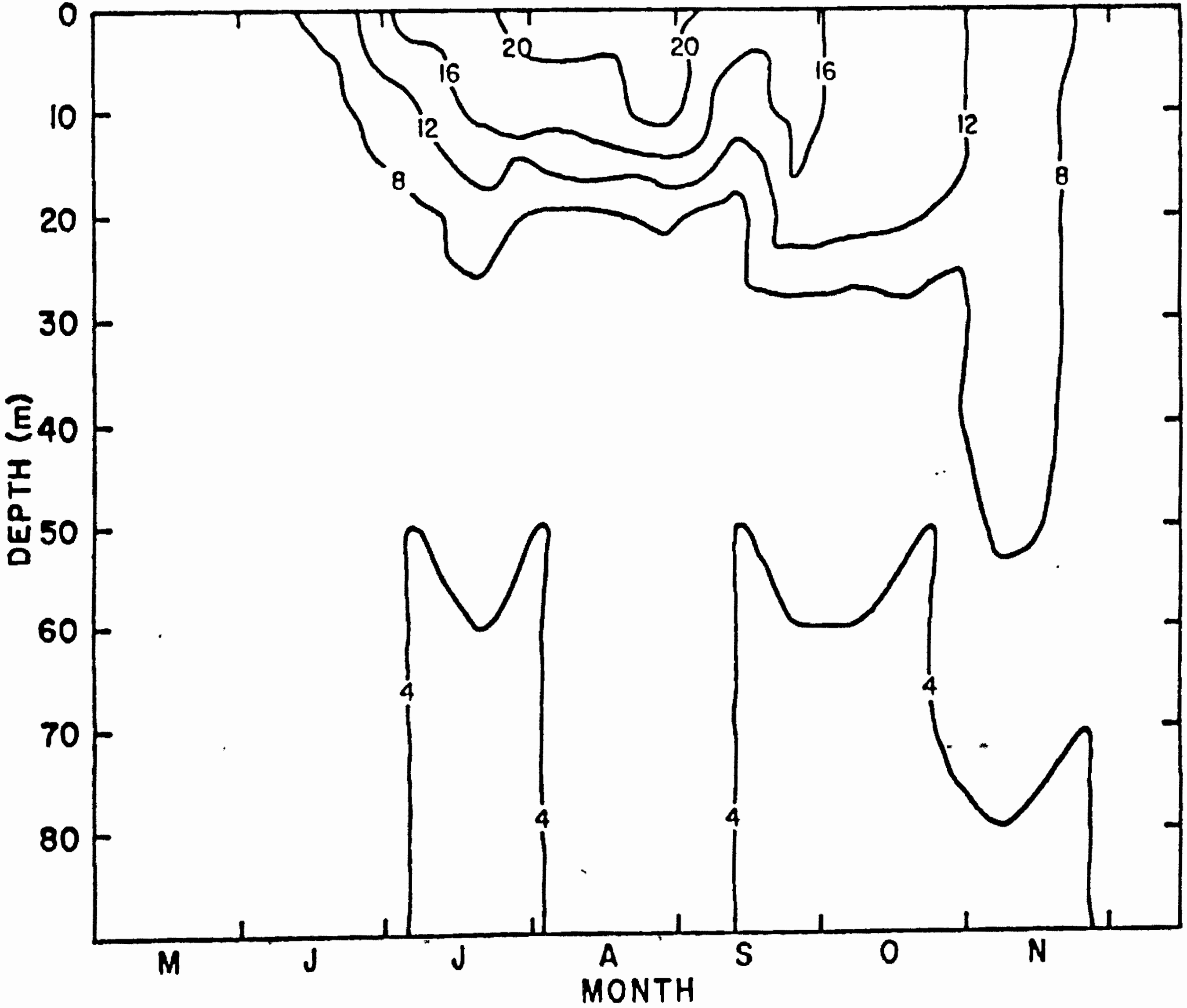


Figure 11. Thermal structure of the 100 m station in 1984 (reproduced from Shea 1987).

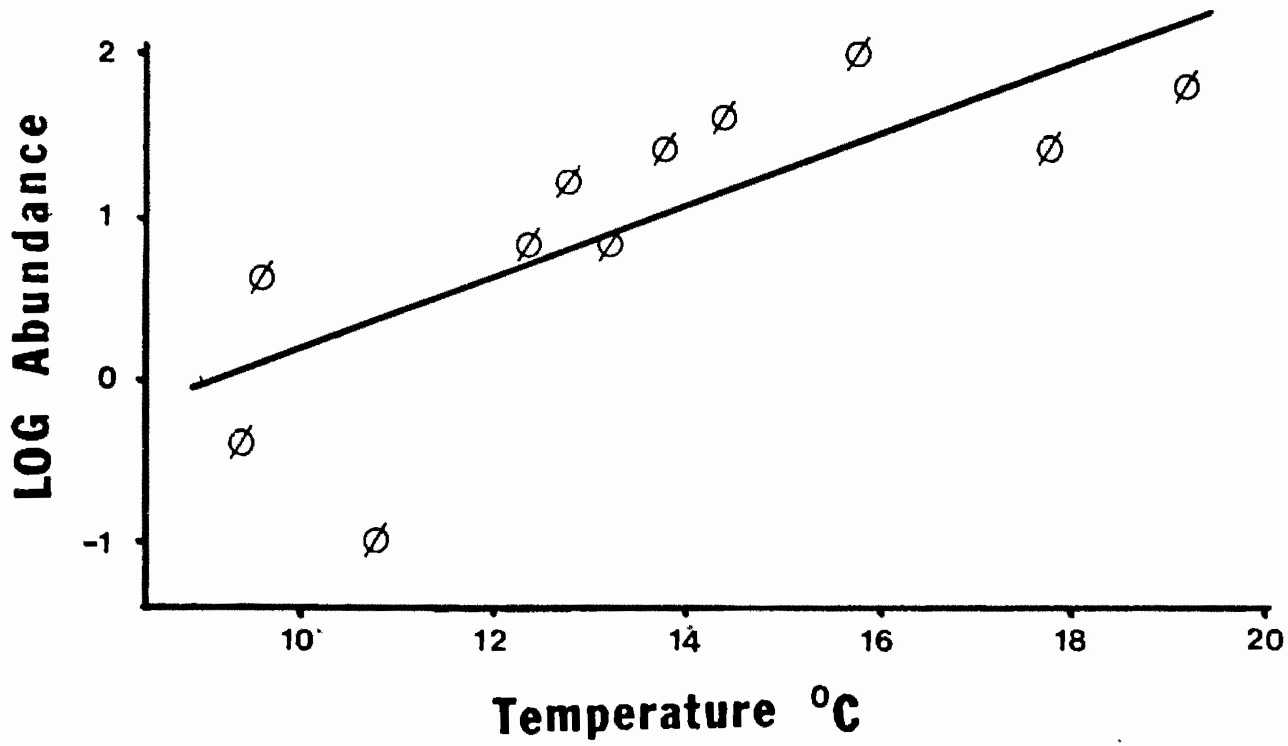


Figure 12. Seasonal <u>Leptodora</u>'s abundance versus temperature at the 35 m station, 1984. (Log Abundance = -2.16 + 0.227 C, r^2 = 0.59).

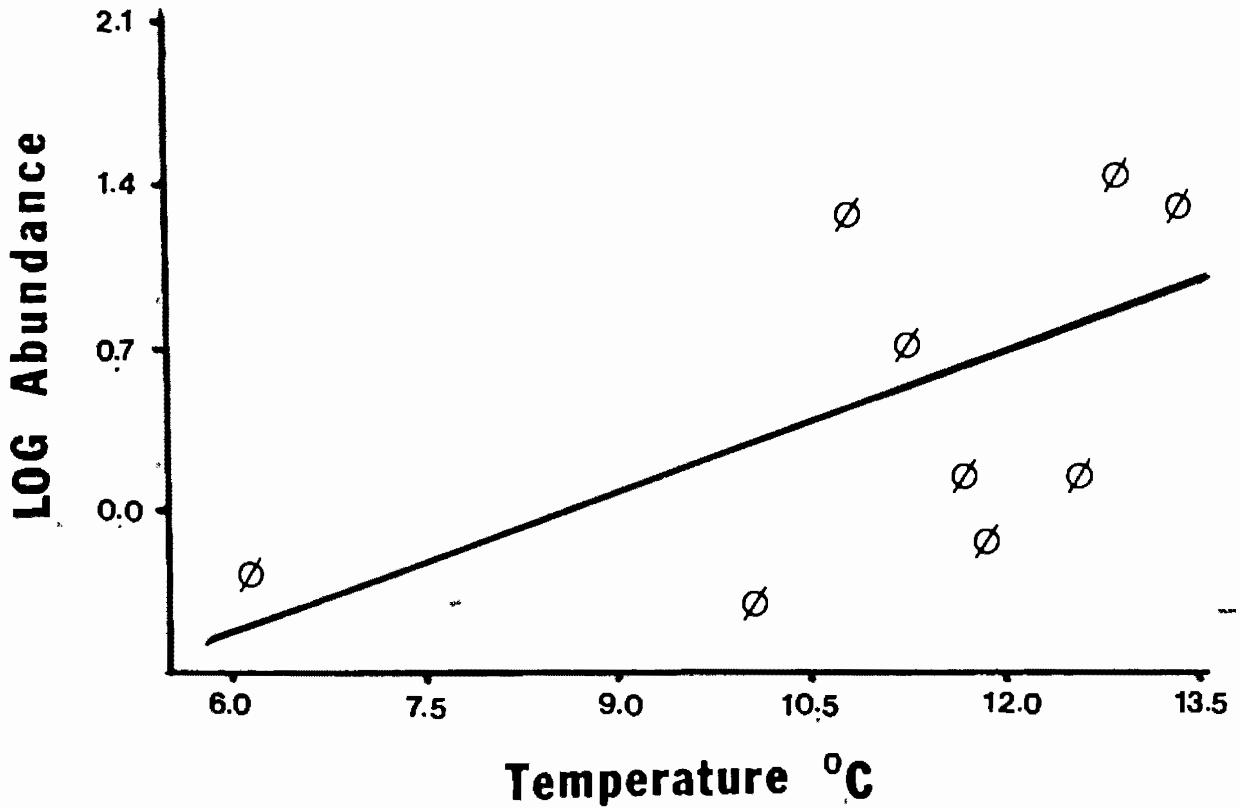


Figure 13. Seasonal *Leptodora*'s abundance versus temperature at the 100 m station, 1984. (Log Abundance = $- 1.57 + 0.185$ C, $r^2 = 0.29$).

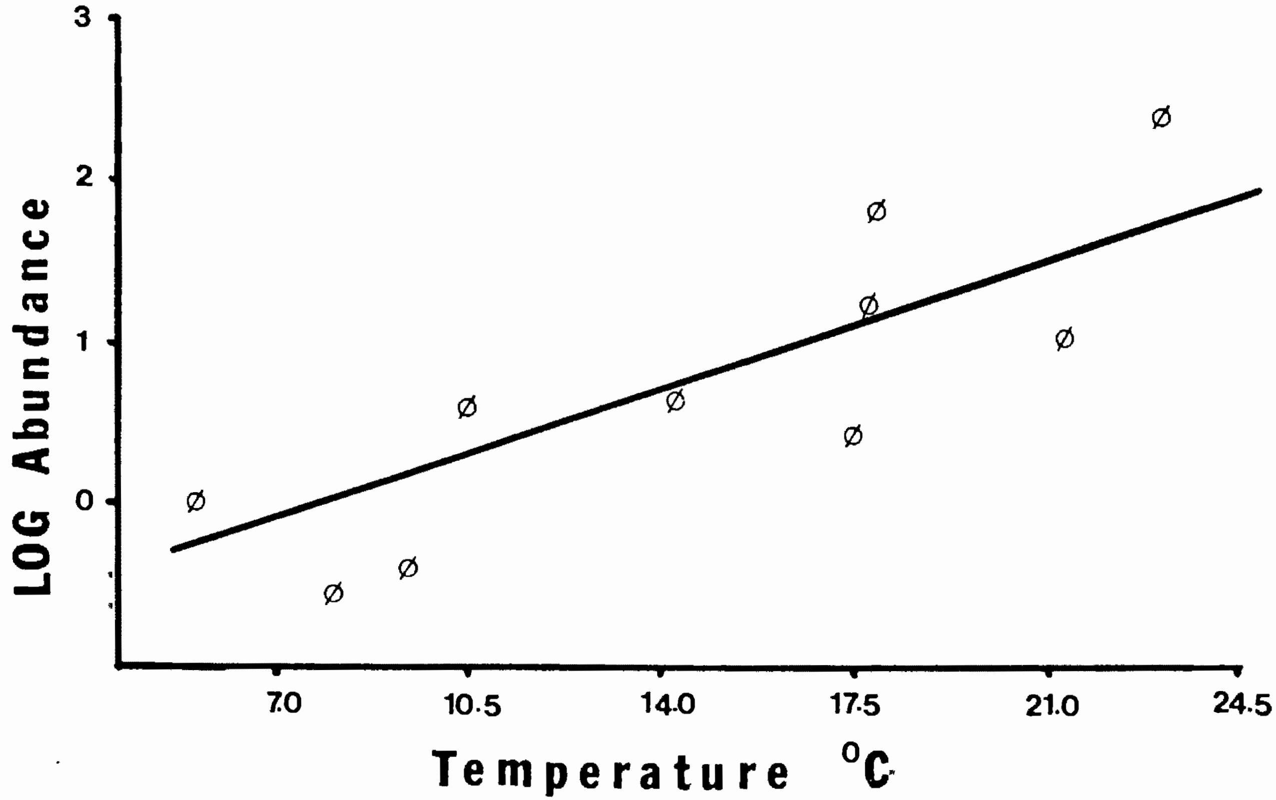


Figure 14. Seasonal <u>Leptodora</u>'s abundance versus temperature at the 10 m station, 1986. (Log Abundance = – 1.20 + 0.132 C, r^2 = 0.67).

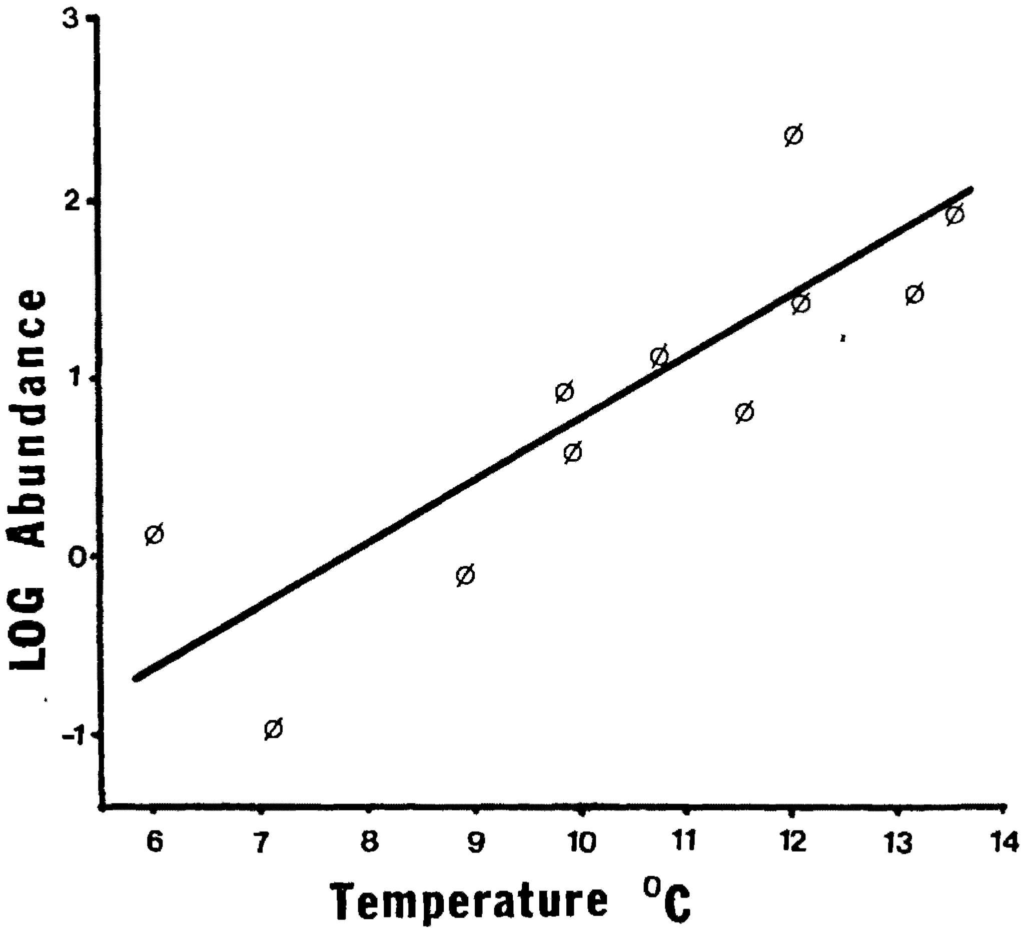


Figure 15. Seasonal Leptodora's abundance versus temperature at the 100 m station, 1987. (Log Abundance = - 2.57 + 0.323 C, $r^2 = 0.67$).

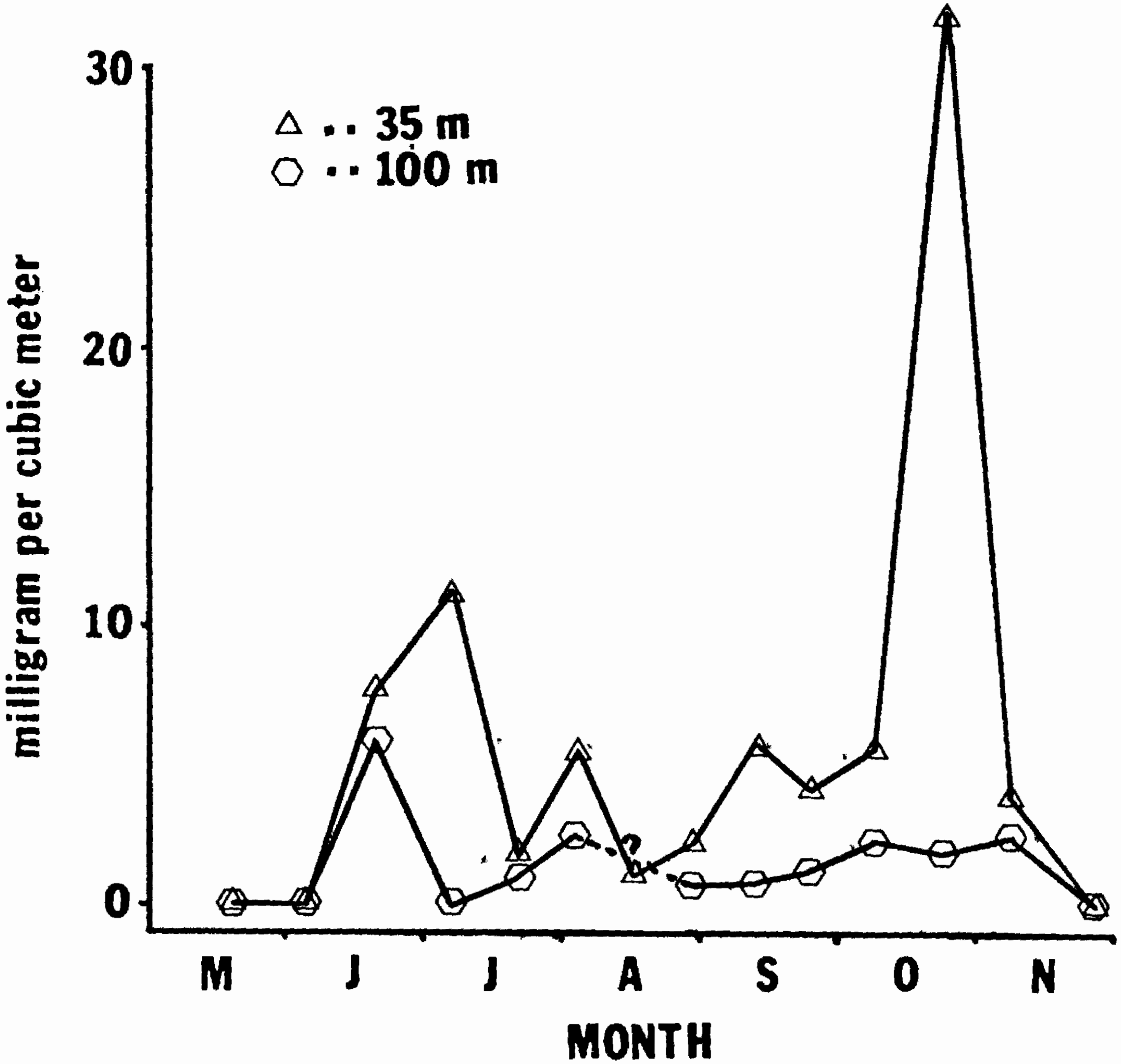


Figure 16. Population biomass of Leptodora kindtii at the 35 m and 100 m stations in 1984.

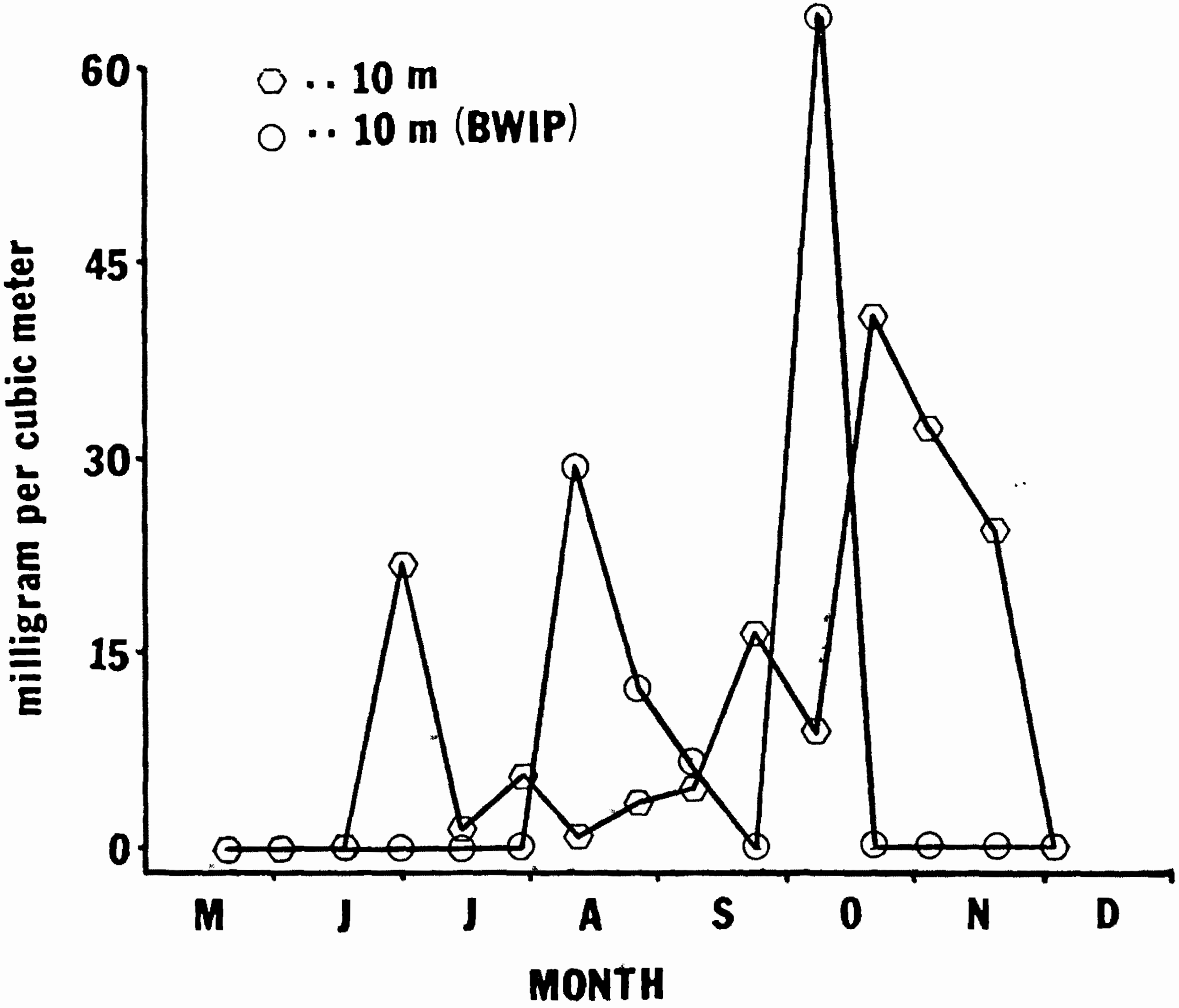


Figure 17. Population biomass of Leptodora kindtii at the 10 m (BWIP) and 10 m stations, 1986.

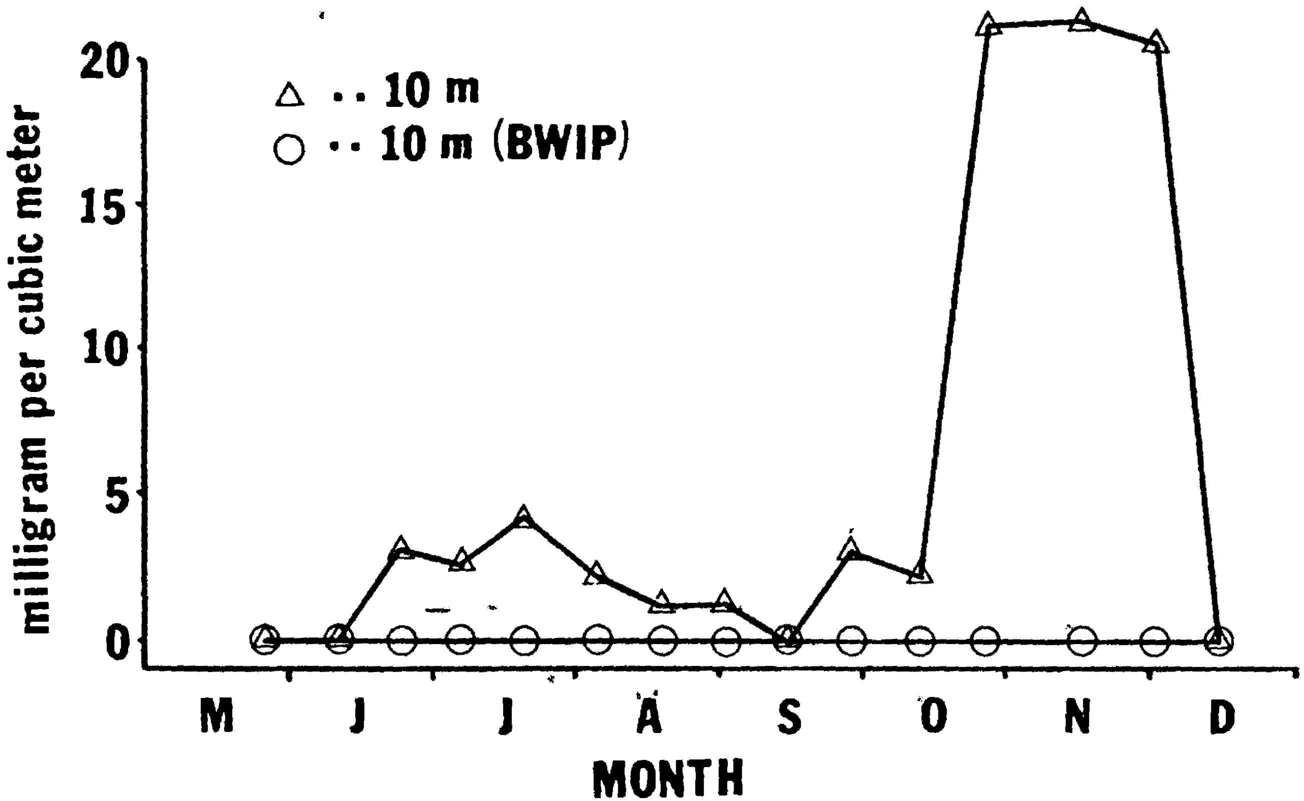


Figure 18. Population biomass of Leptodora kindtii at the 10 m (BWIP) and 100 m stations in 1987.

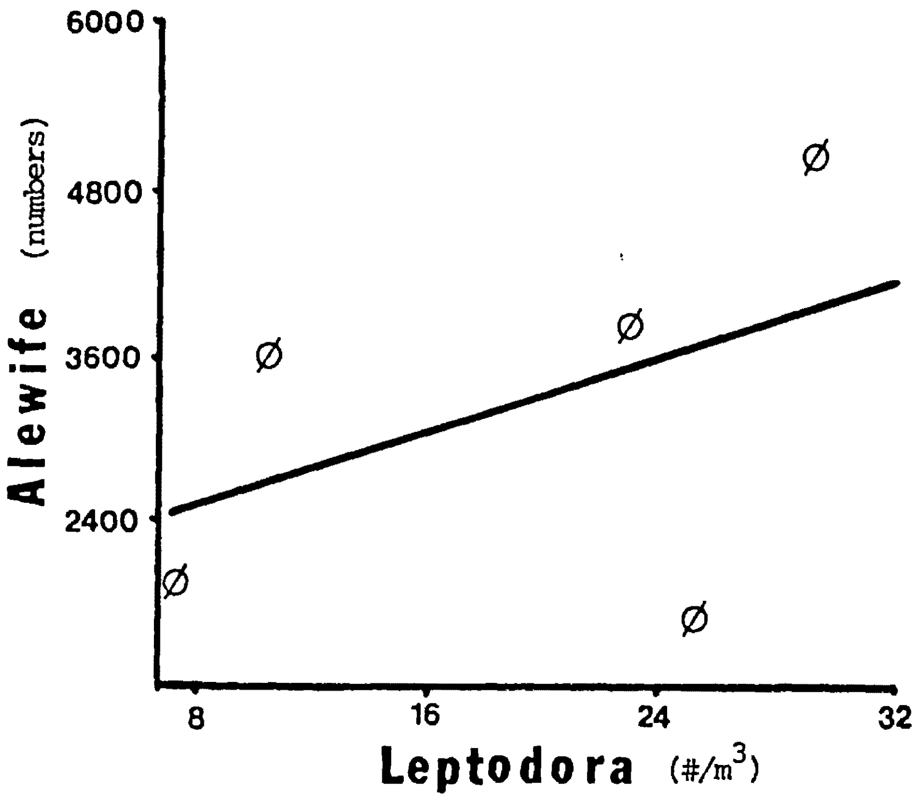
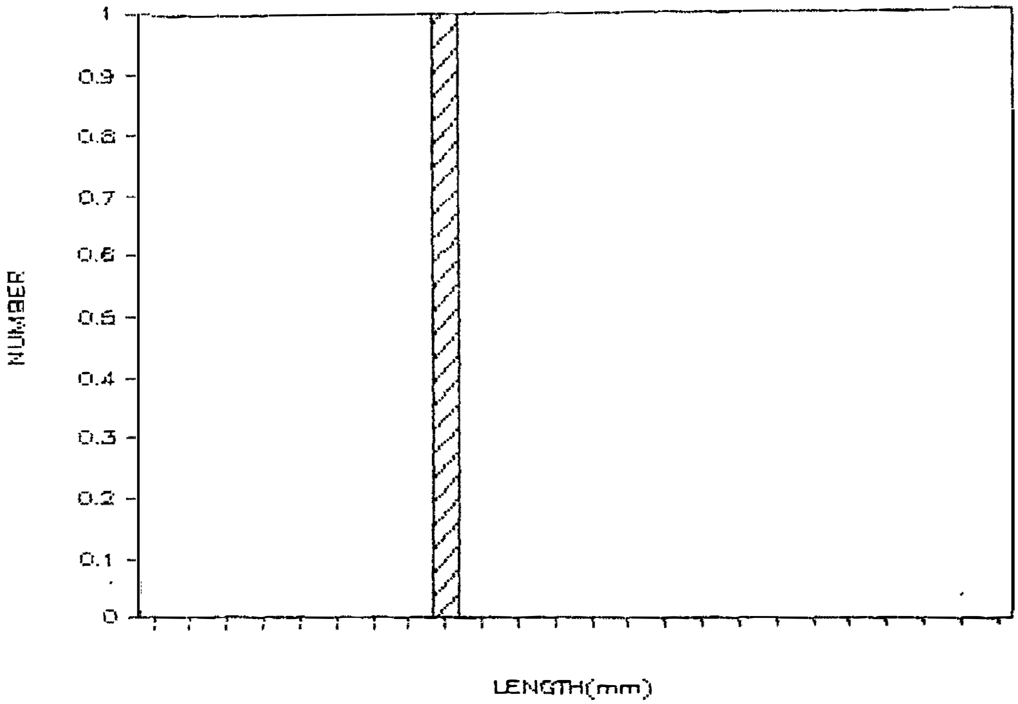


Figure 19. Coefficient correlation between the annual alewife and *Leptodora* abundances. (Alewife = 1969 + 67.7 Leptodora, r^2 = 0.22)

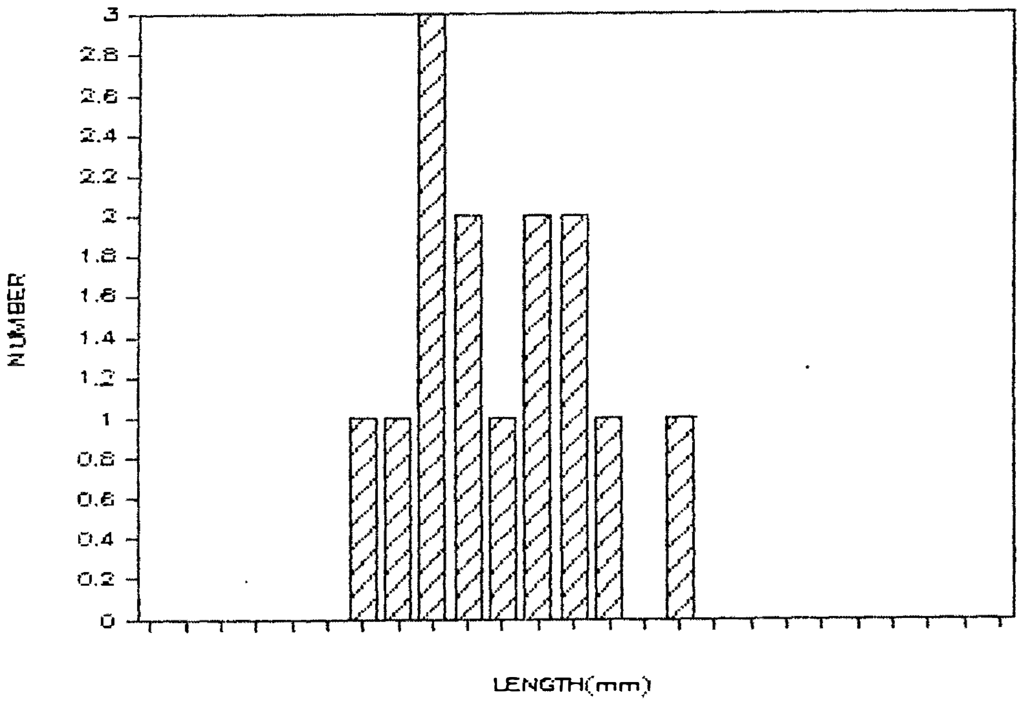
APPENDIX 1

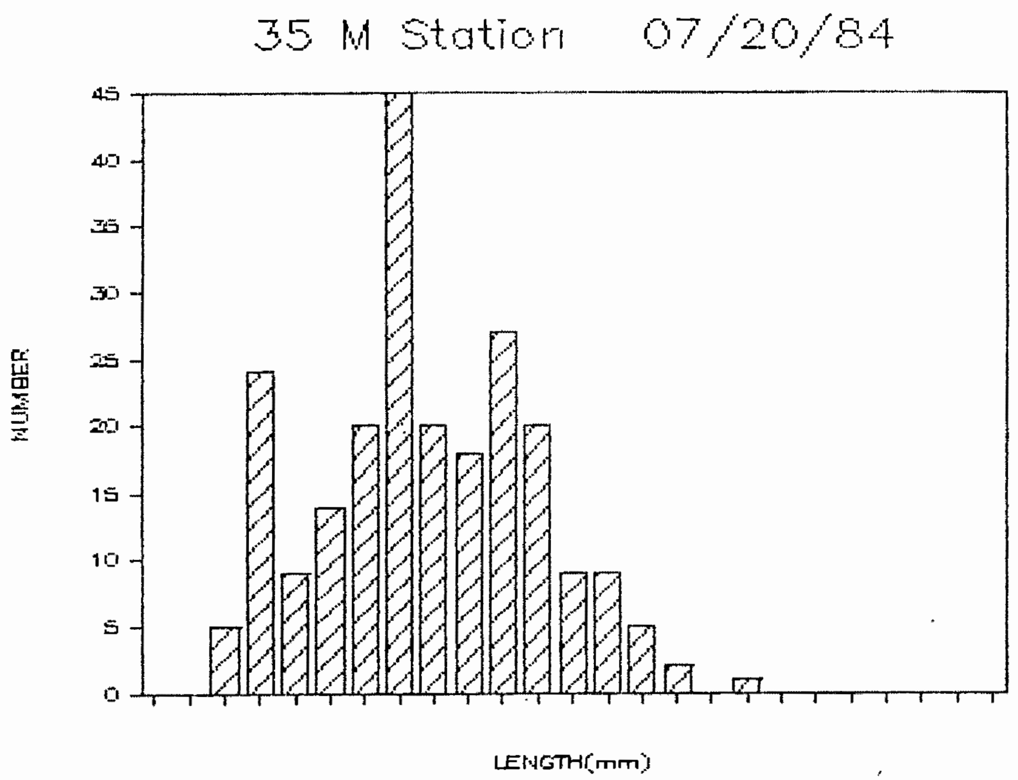
Size frequency diagrams of Leptodora kindtii (Focke)
at the 35 m station in 1984

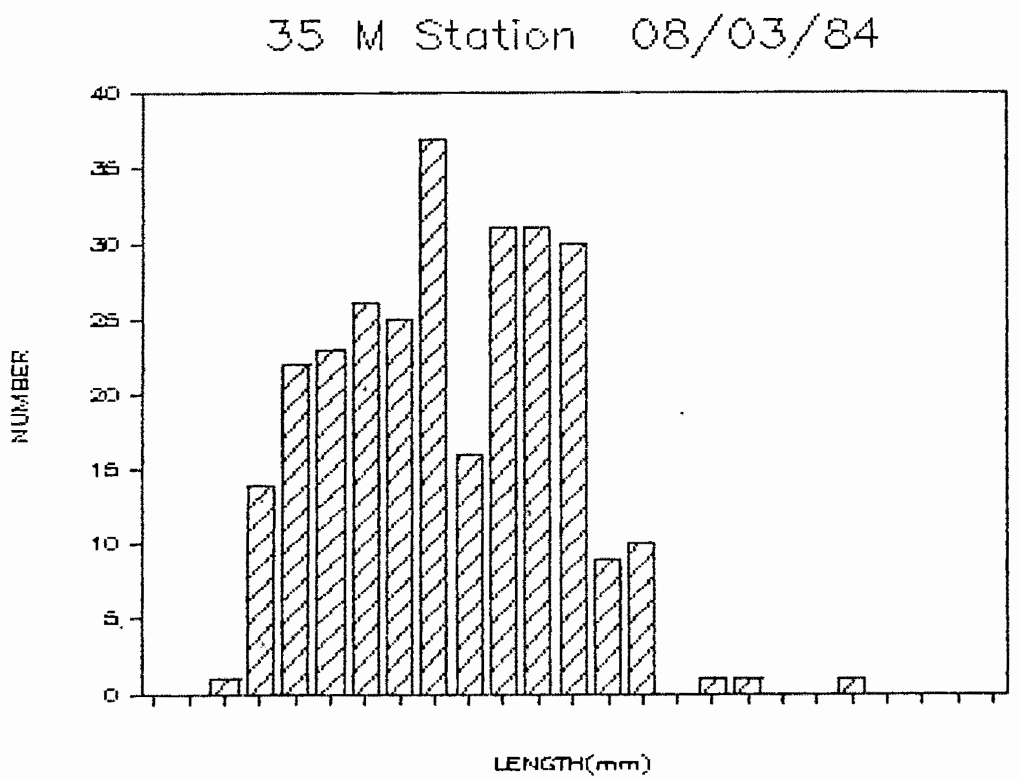
35 M Station 06/19/1984

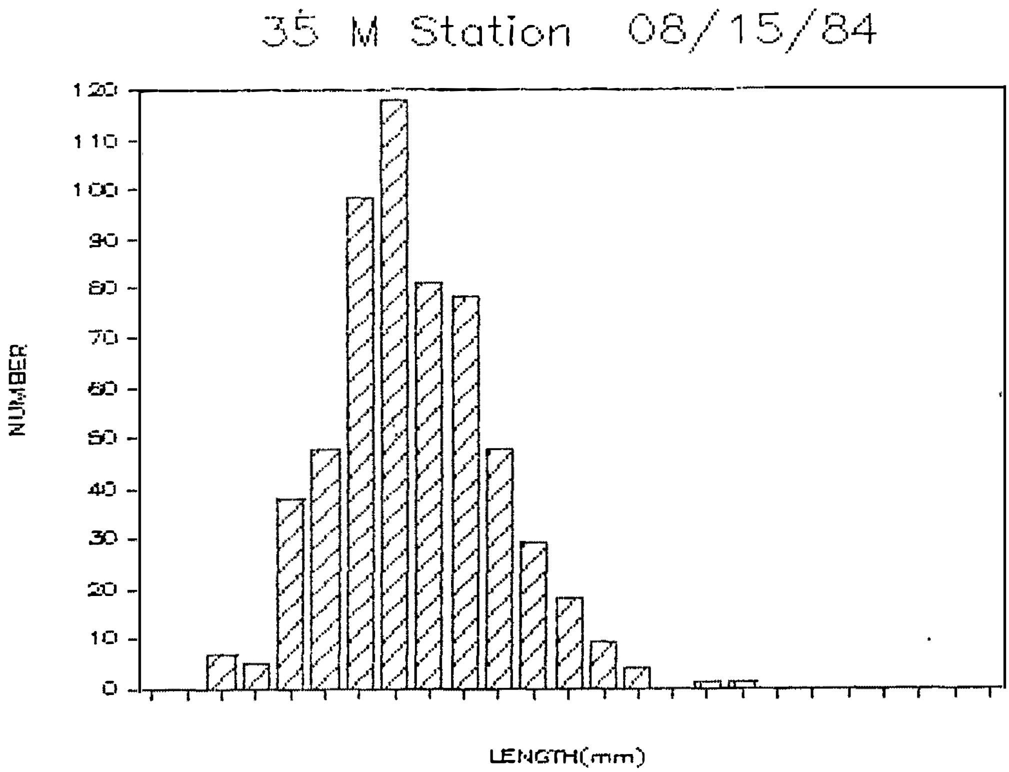


35 M Station 07/06/84

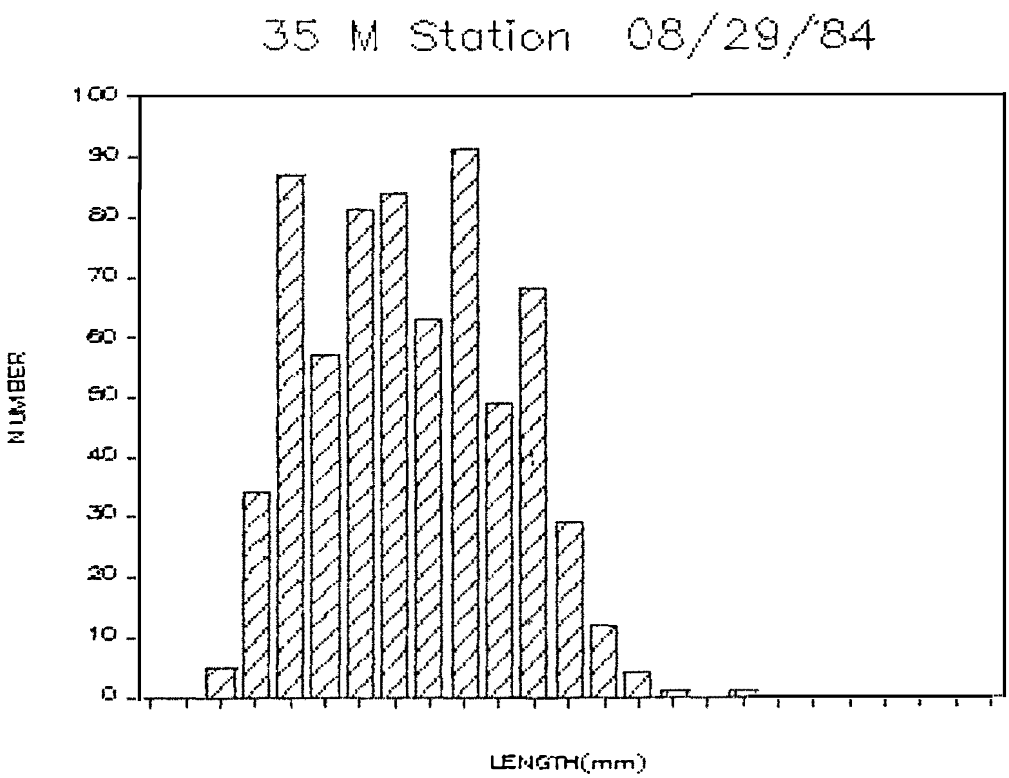



35 M Station 07/20/84
NUMBER
LENGTH(mm)
0
5
10
15
20
25
30
35
40
45

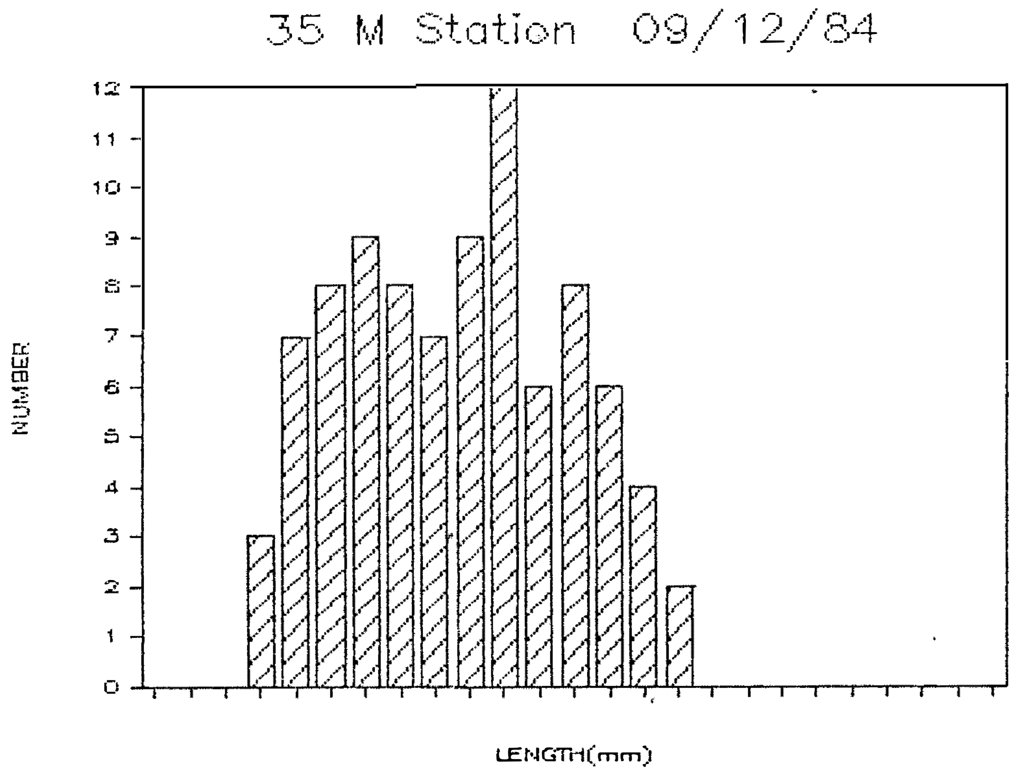

35 M Station 08/03/84
NUMBER
LENGTH(mm)
0
5
10
15
20
25
30
35
40



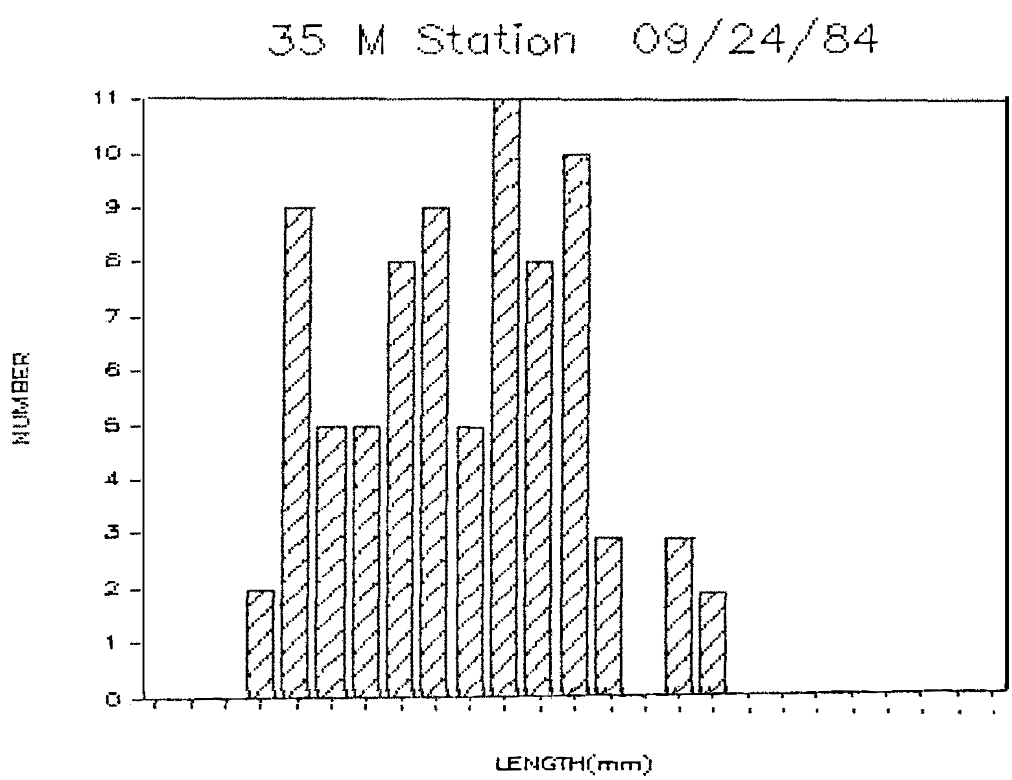
35 M Station 08/15/84
NUMBER
0
10
20
30
40
50
60
70
80
90
100
110
120
LENGTH(mm)



35 M Station 08/29/84
NUMBER
0
10
20
30
40
50
60
70
80
90
100
LENGTH(mm)

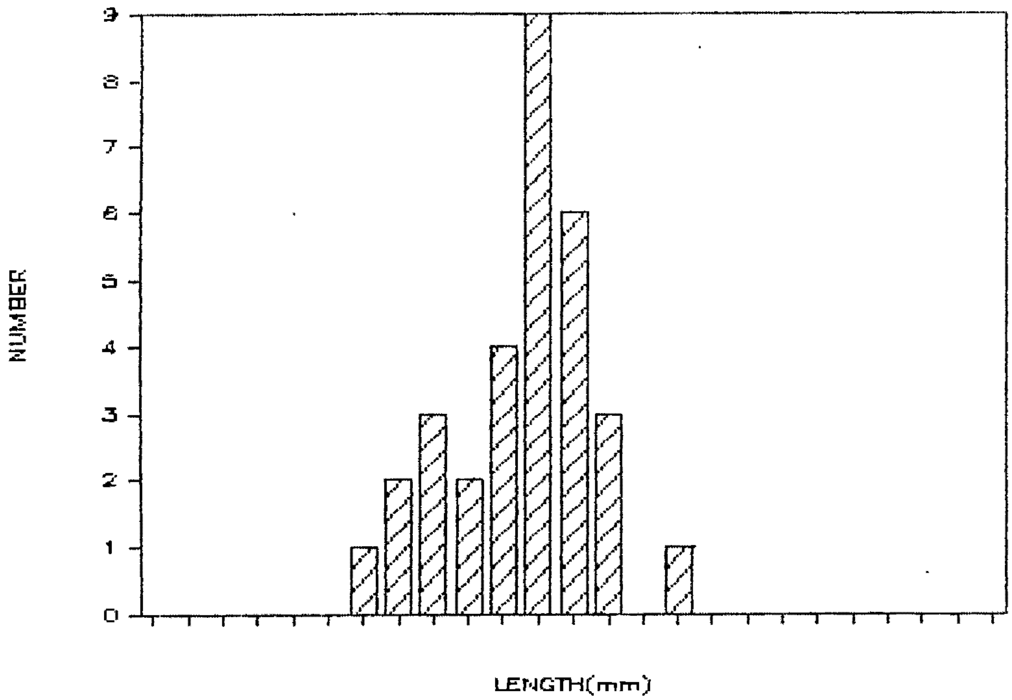


35 M Station 09/12/84
NUMBER
0
1
2
3
4
5
6
7
8
9
10
11
12
LENGTH(mm)

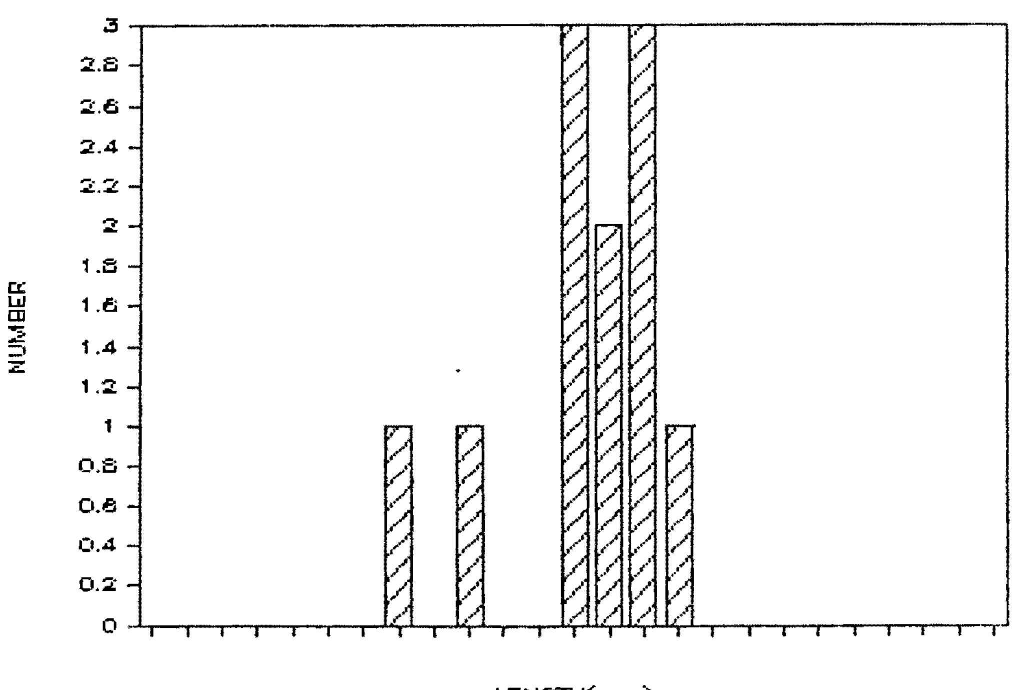


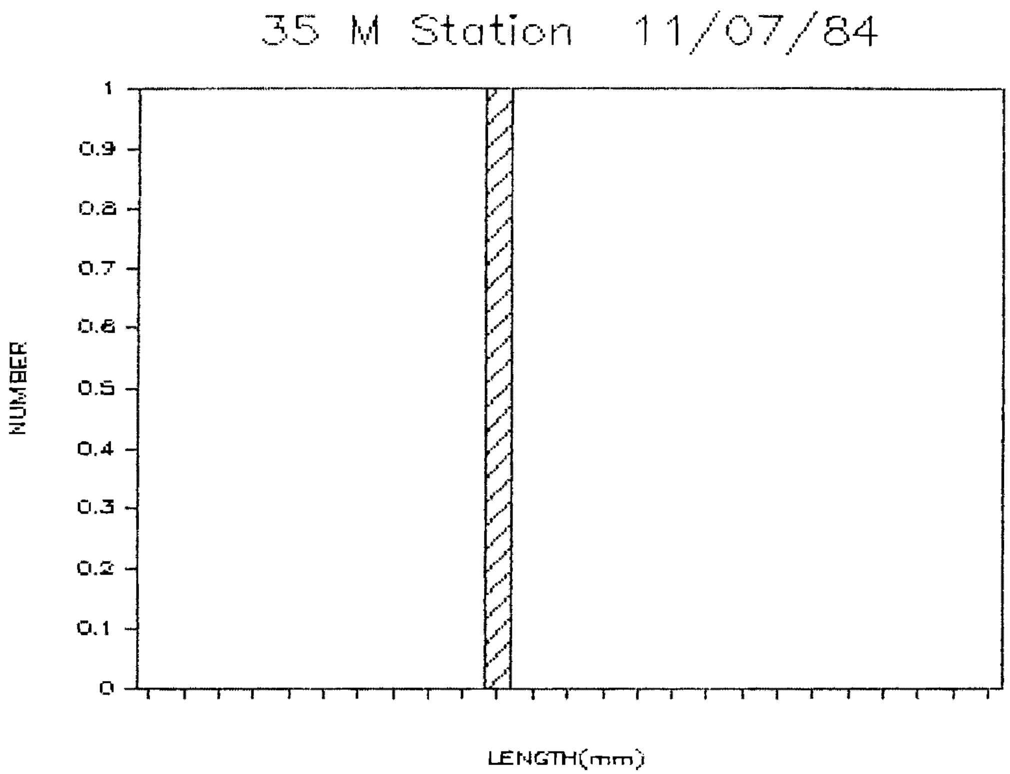
35 M Station 09/24/84
NUMBER
0
1
2
3
4
5
6
7
8
9
10
11
LENGTH(mm)

35 M Station 10/08/84



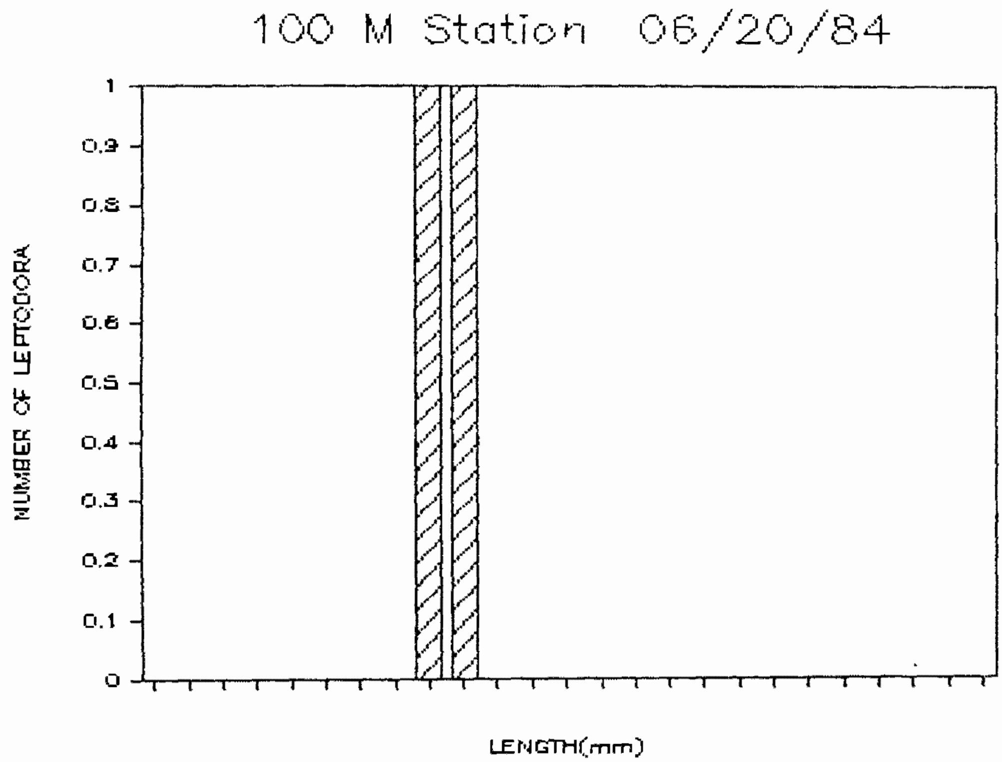
35 M Station 10/23/84

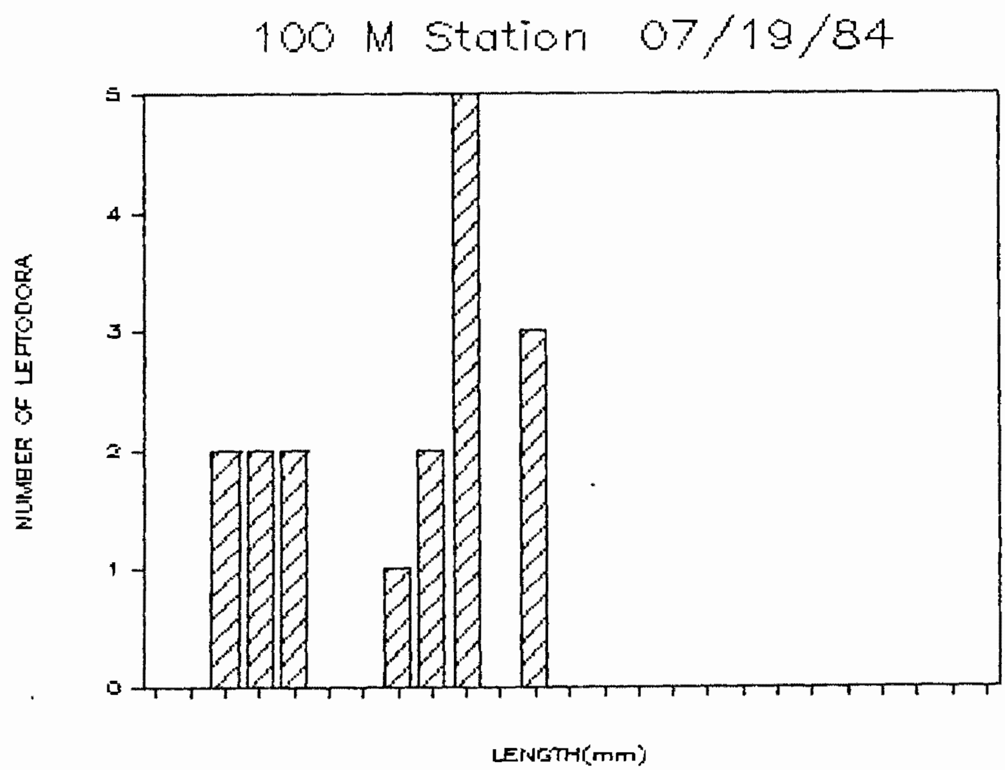



35 M Station 11/07/84
NUMBER
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
LENGTH(mm)

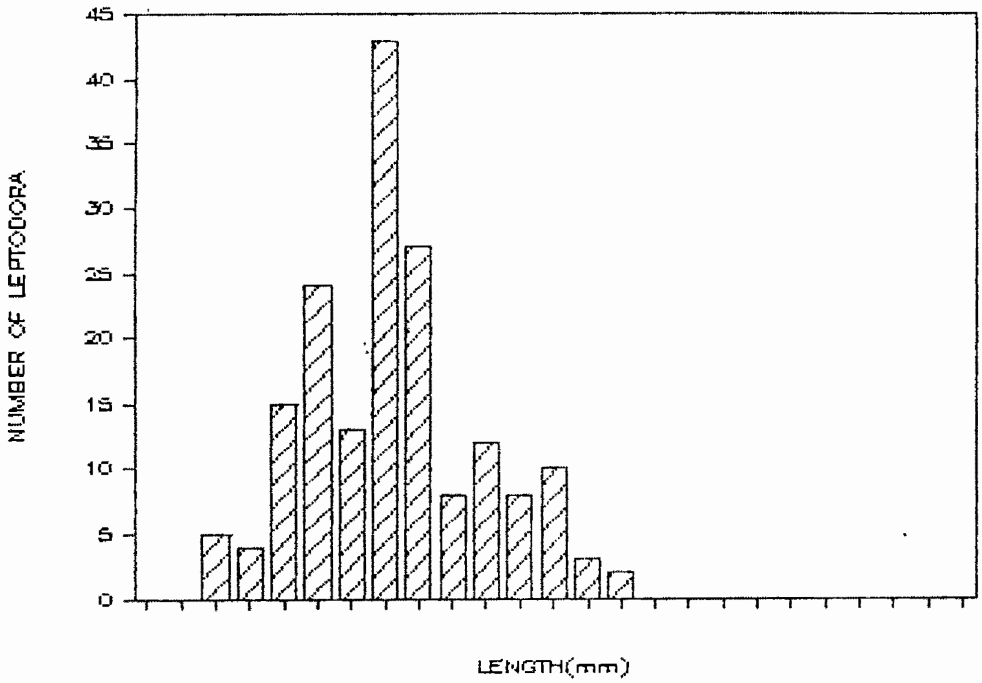
APPENDIX 2

Size frequency diagrams of Leptodora kindtii (Focke) at the 100 m station in 1984.

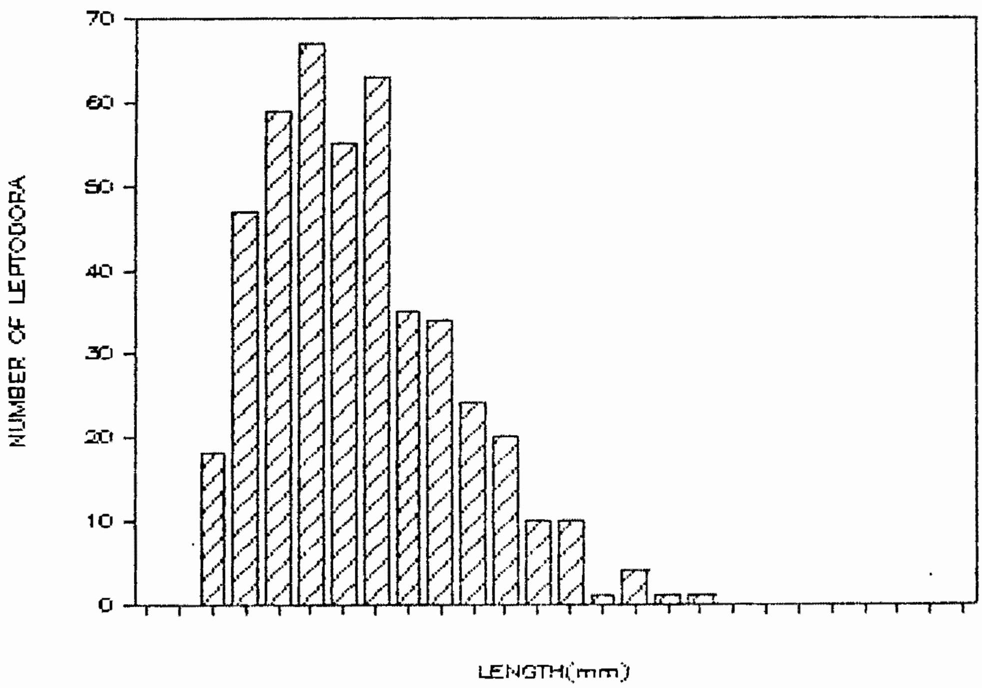

100 M Station 06/20/84
NUMBER OF LEPTODORA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
LENGTH(mm)


100 M Station 07/19/84
NUMBER OF LEPTODORA
5
4
3
2
1
0
LENGTH(mm)

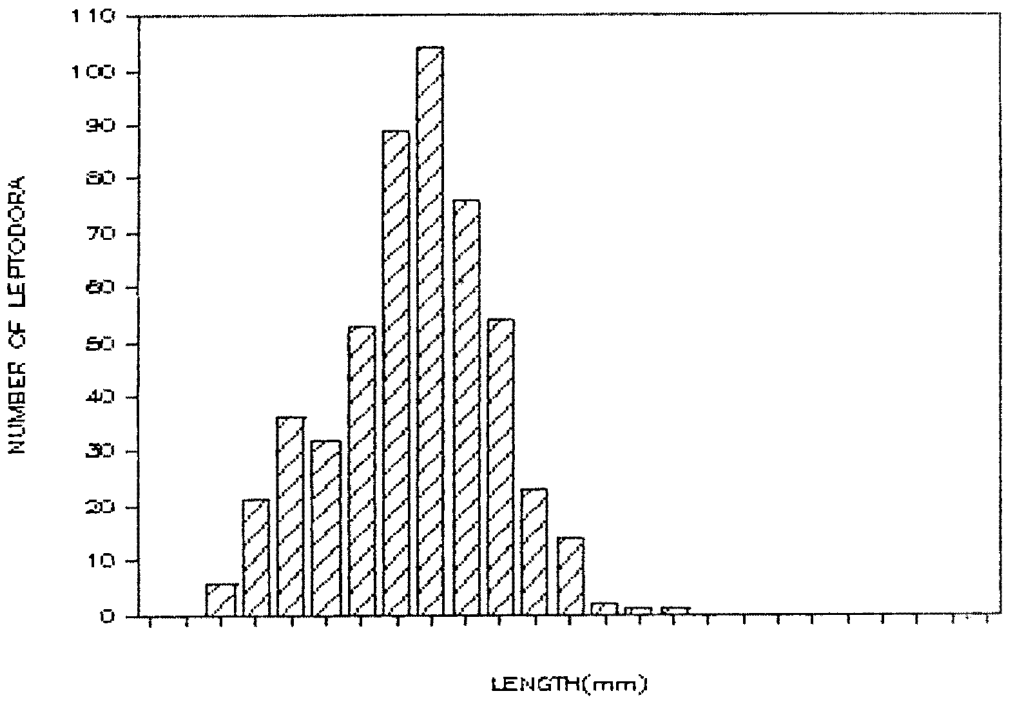
100 M Station 08/02/84



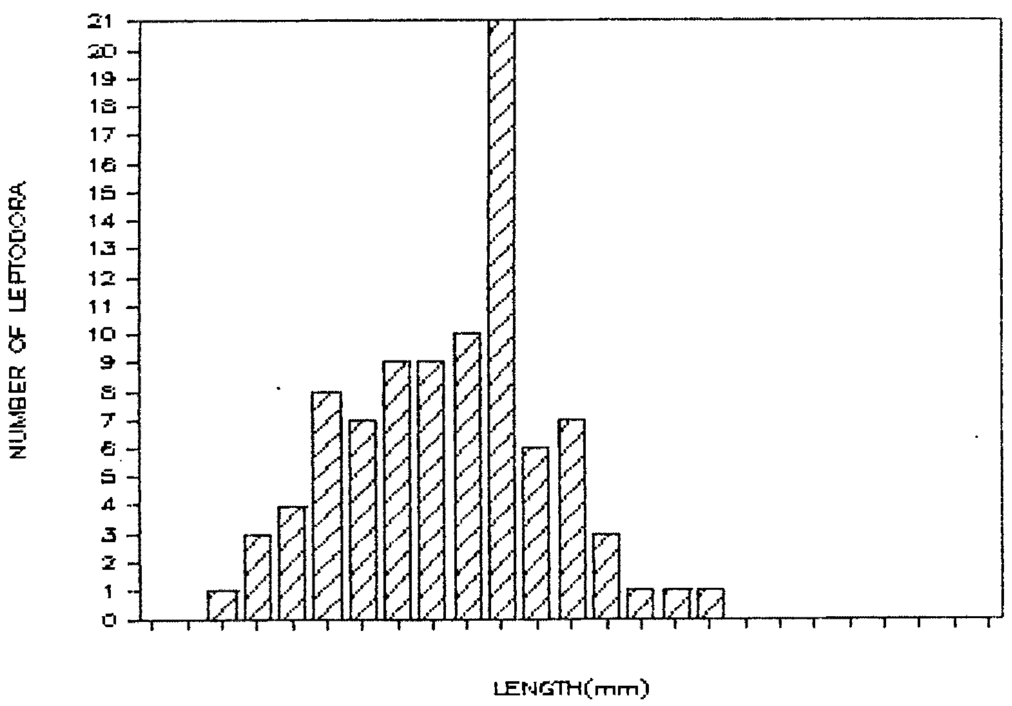
100 M Station 08/29/84

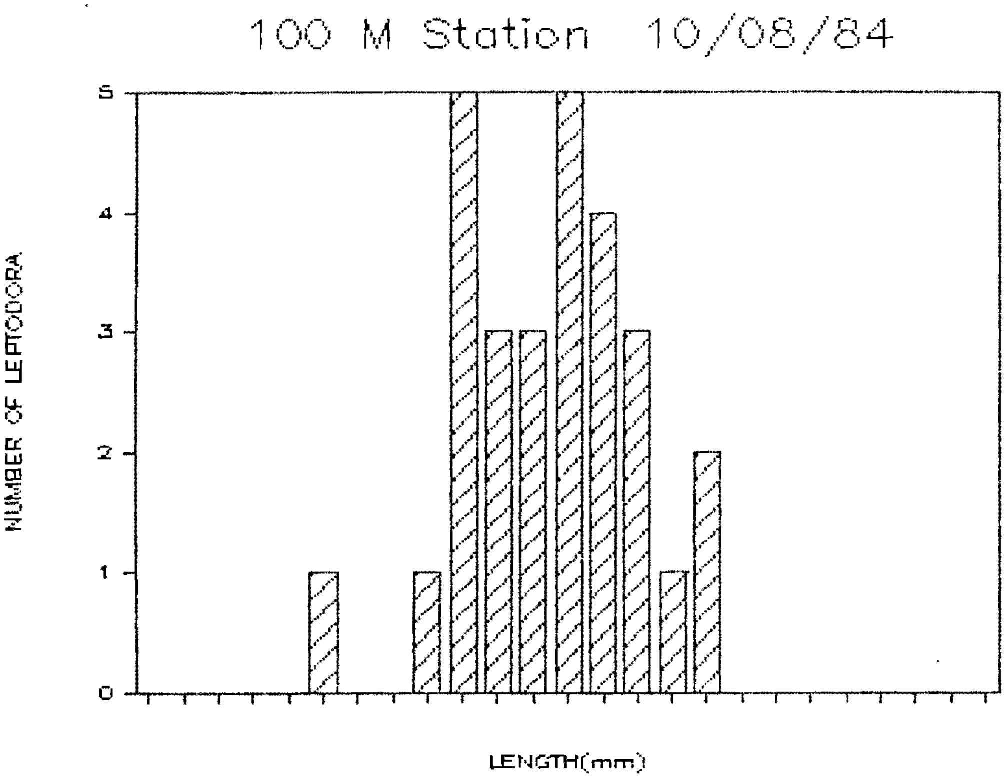


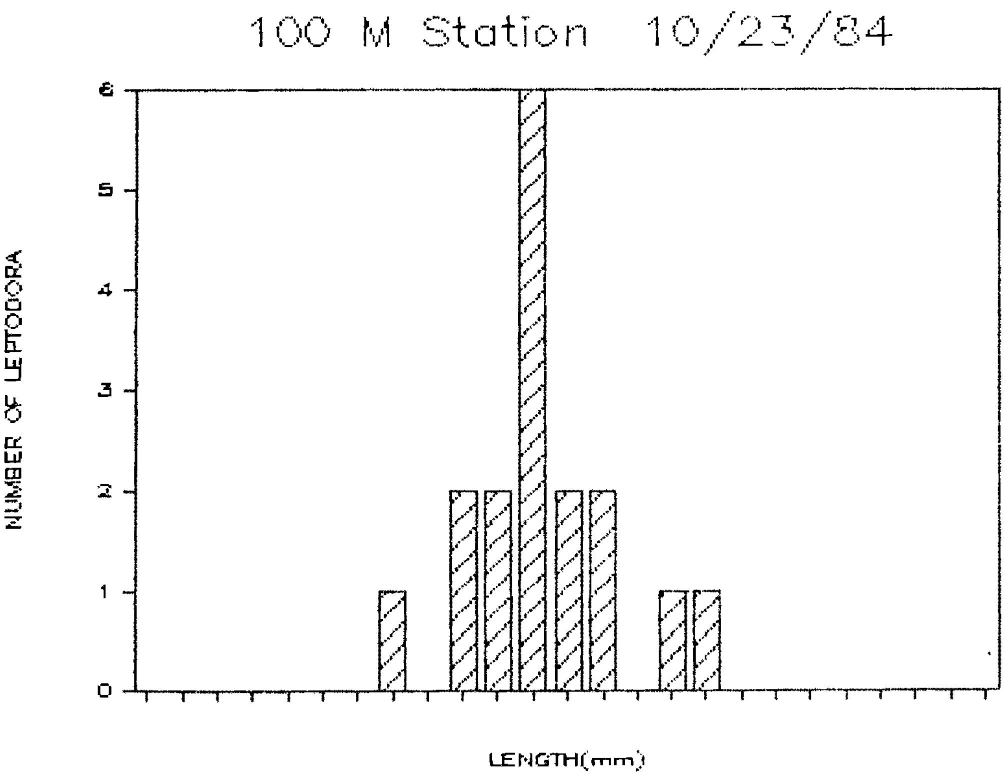
100 M Station 09/12/84

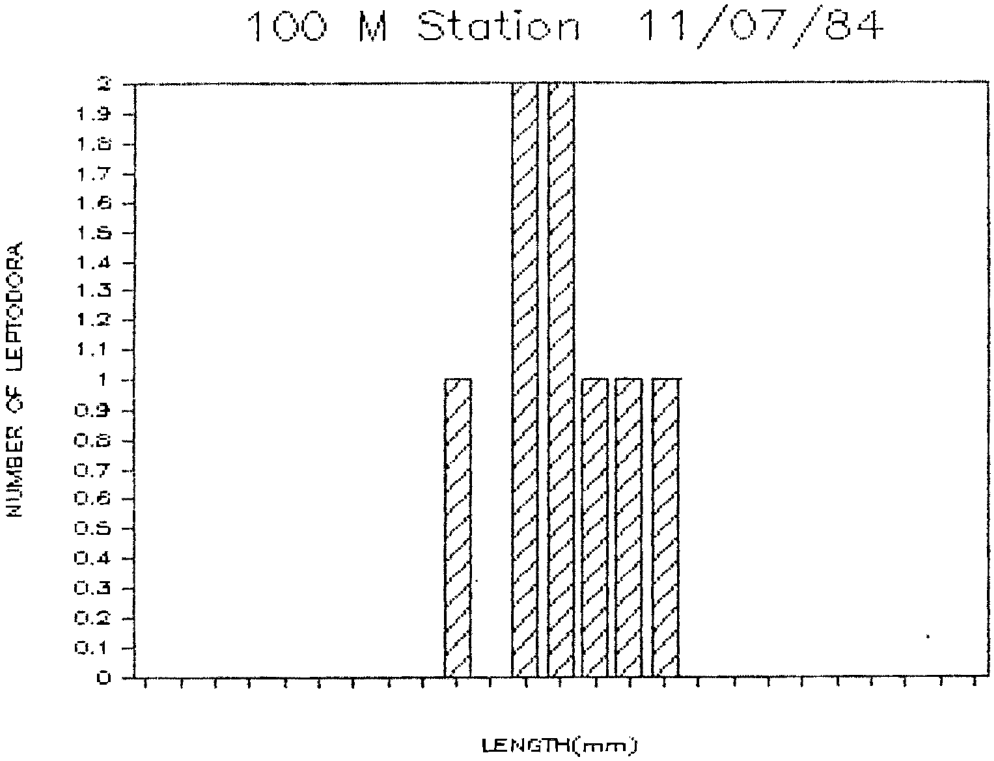


100 M Station 09/25/84




100 M Station 10/08/84
NUMBER OF LEPTODORA
LENGTH(mm)
0
1
2
3
4
5


100 M Station 10/23/84
NUMBER OF LEPTODORA
LENGTH(mm)
0
1
2
3
4
5
6

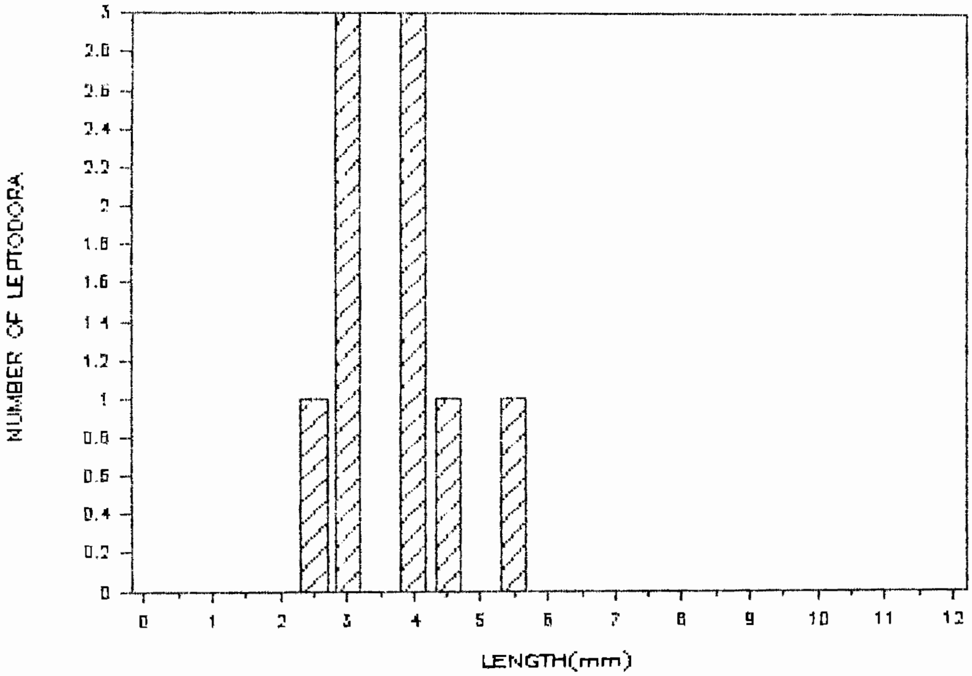


100 M Station 11/07/84
NUMBER OF LEPTODORA
LENGTH(mm)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

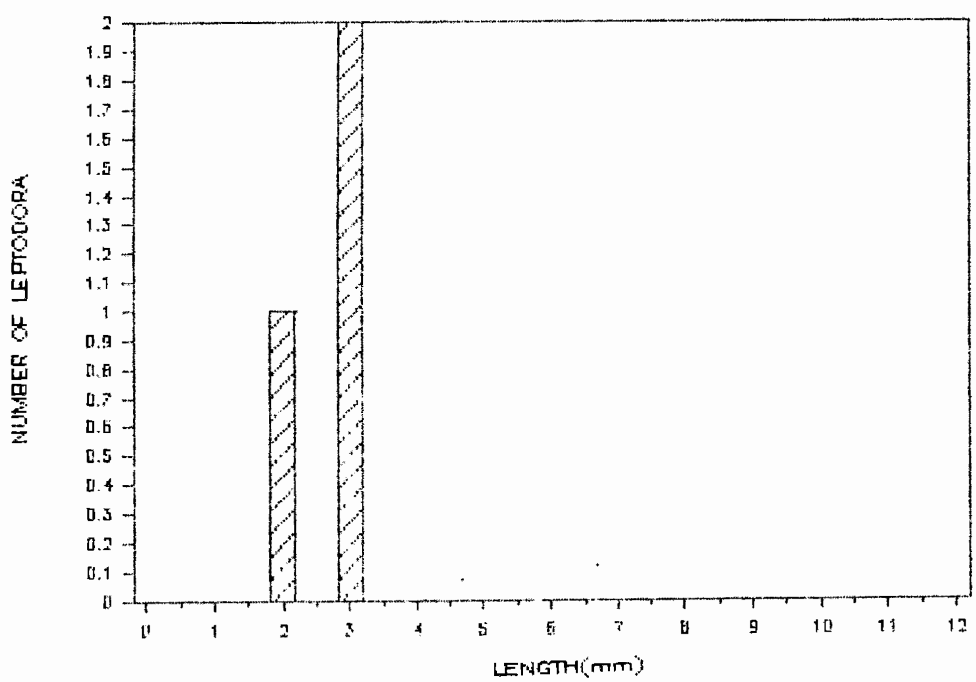
APPENDIX 3

Size frequency diagrams of Leptodora kindtii (Focke) at the 10 m station inside the Brockport Water Intake Plant, 1986.

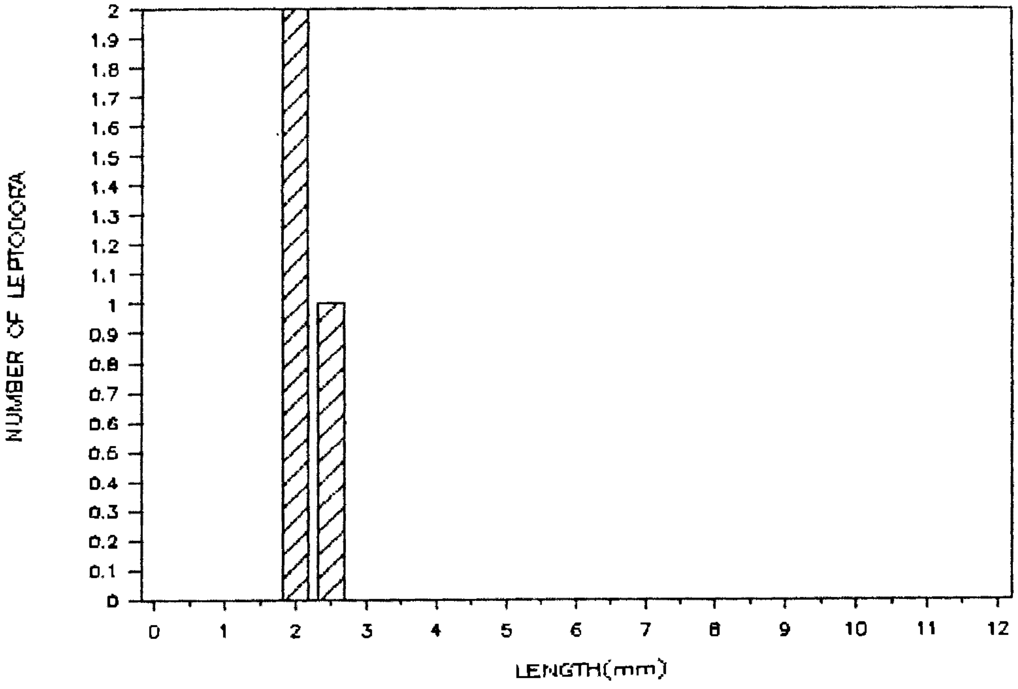
10 M (BWIP) Station 08/11/86



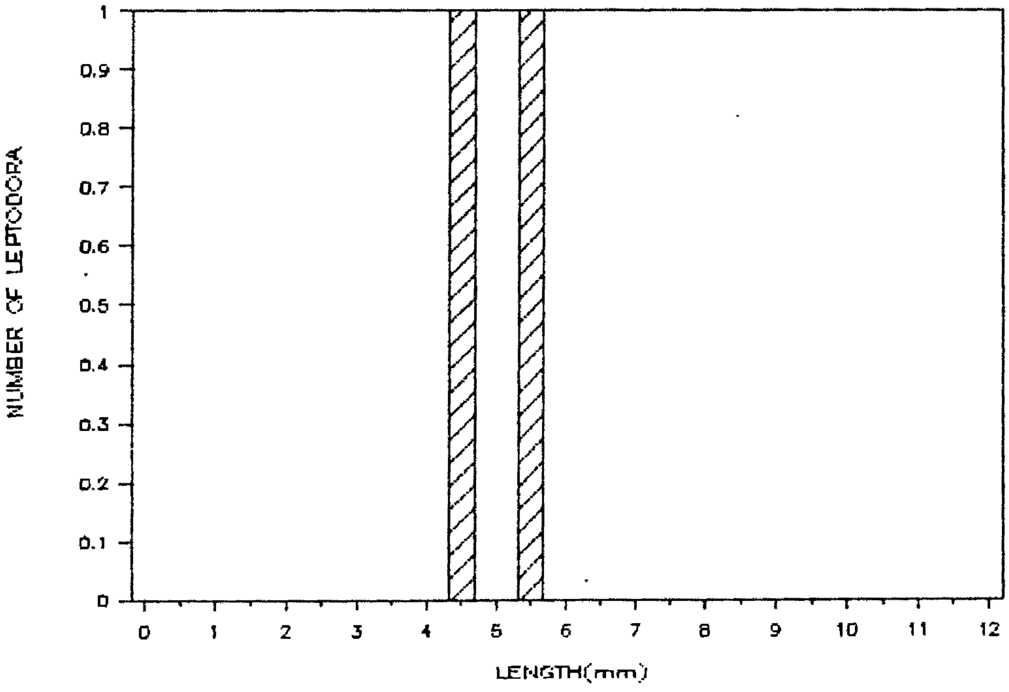
10 M (BWIP) Station 08/25/86



10 M (BWIP) Station 09/08/86

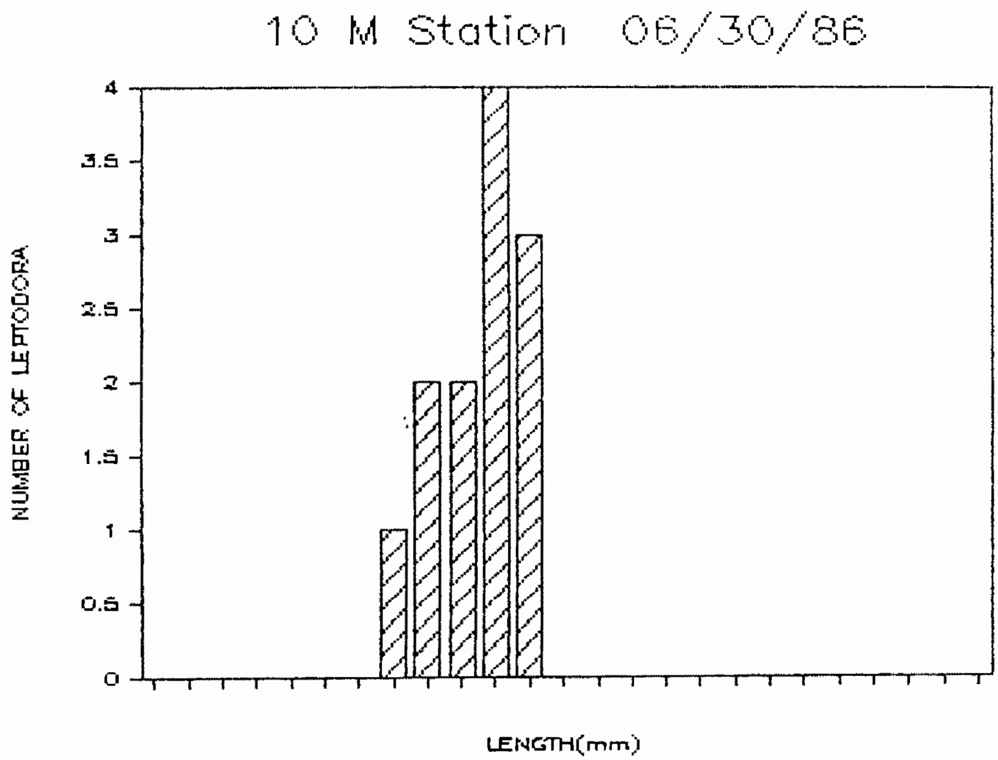


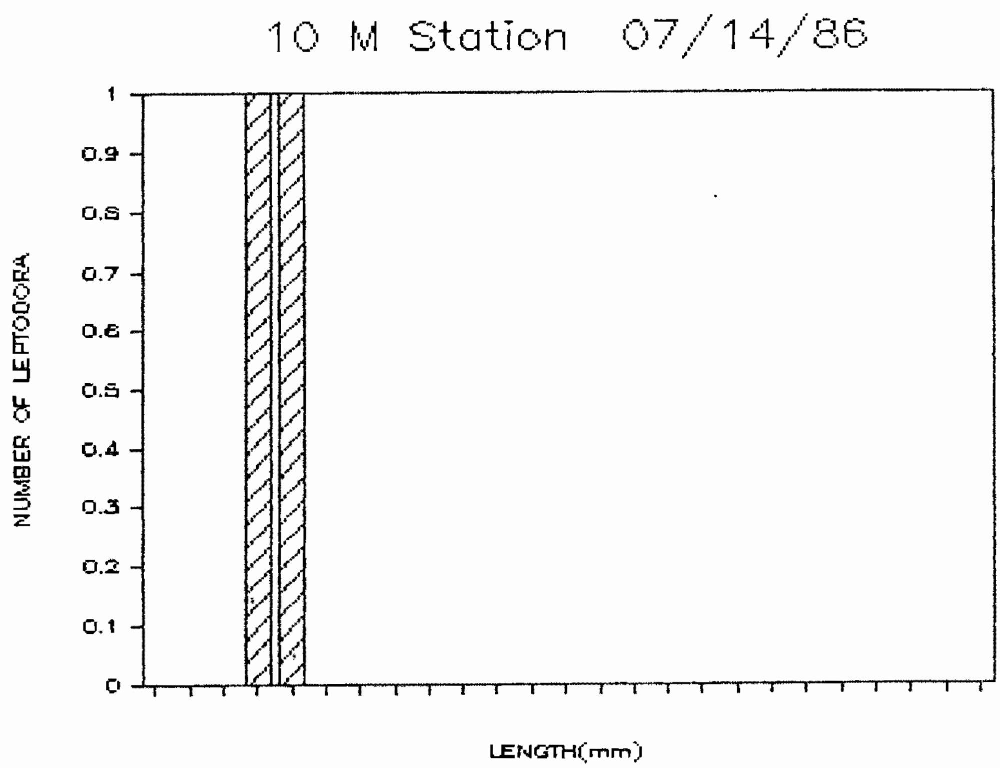
10 M (BWIP) Station 10/07/86

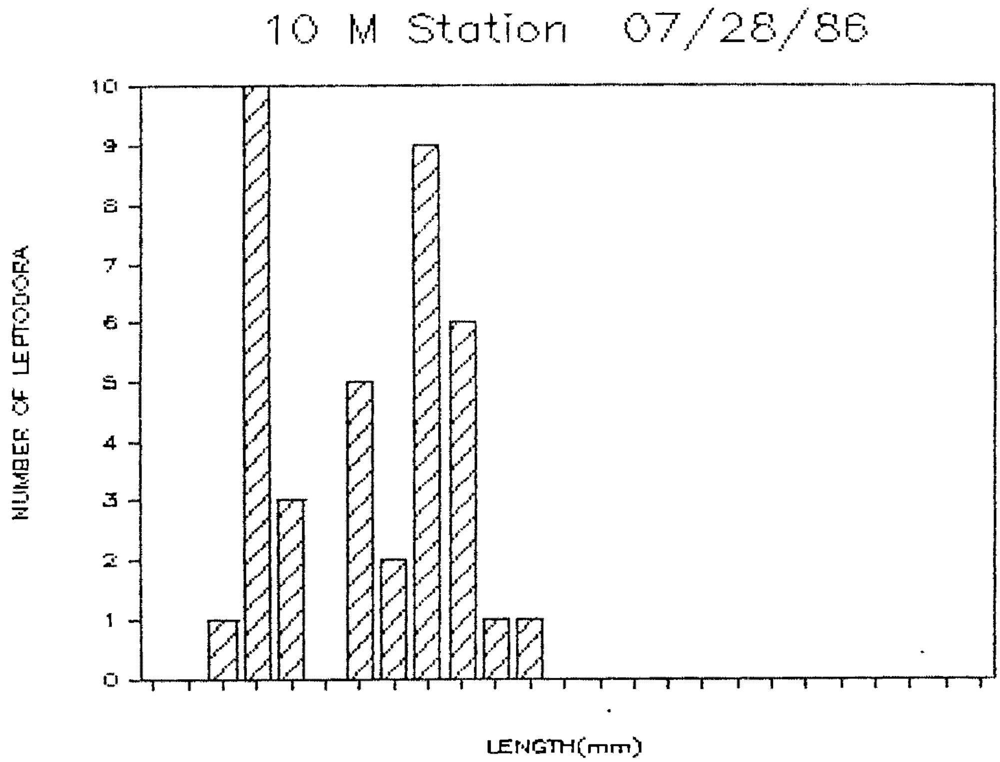


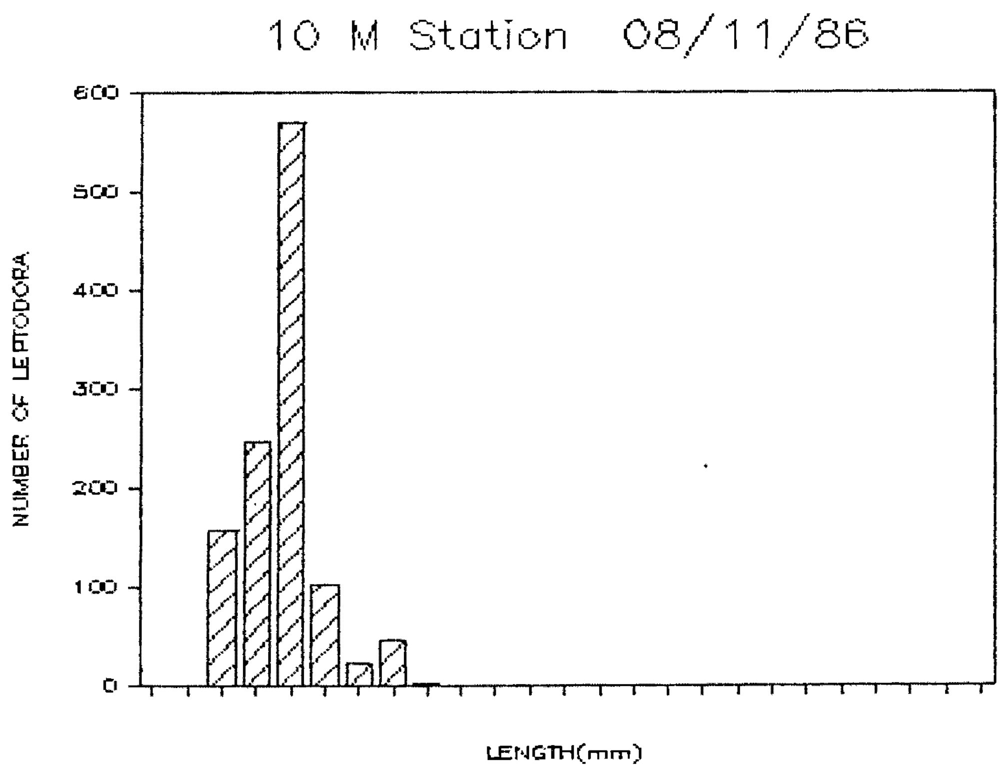
APPENDIX 4

Size frequency diagrams of _Leptodora kindtii_ at the 10 m station in 1986.

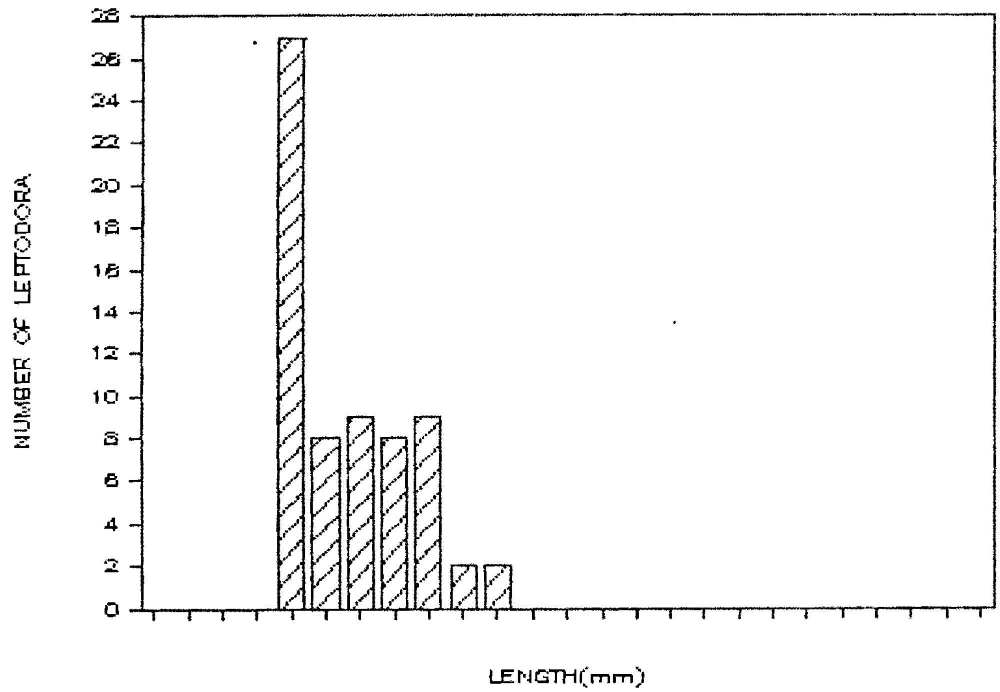

10 M Station 06/30/86
NUMBER OF LEPTODORA
4
3.5
3
2.5
2
1.5
1
0.5
0
LENGTH(mm)


10 M Station 07/14/86
NUMBER OF LEPTODORA
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
LENGTH(mm)

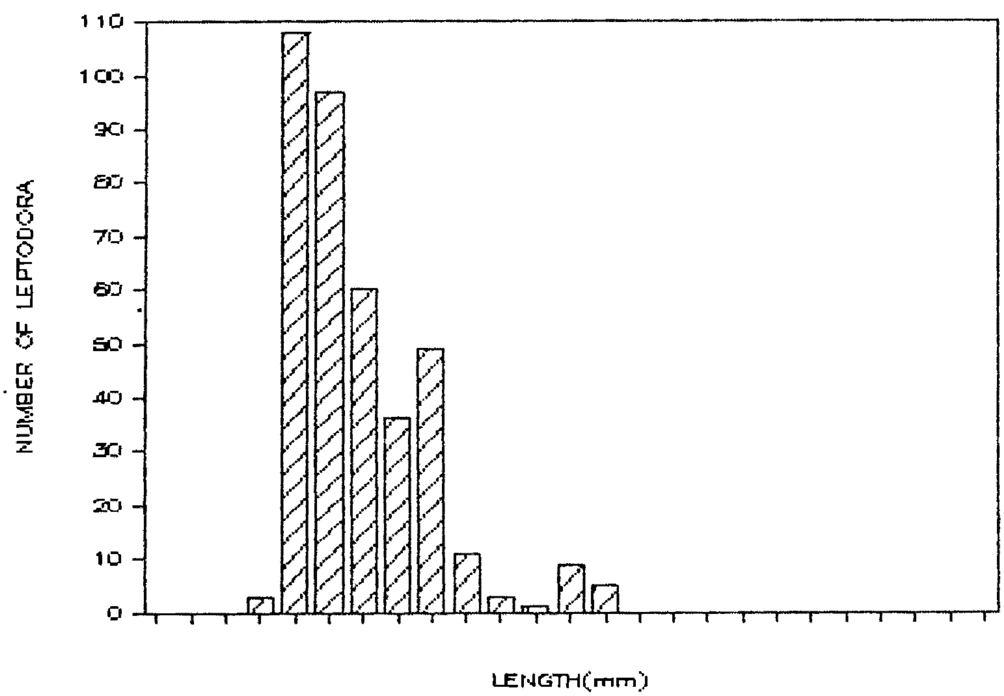

10 M Station 07/28/86
NUMBER OF LEPTODORA
LENGTH(mm)
0
1
2
3
4
5
6
7
8
9
10


10 M Station 08/11/86
NUMBER OF LEPTODORA
LENGTH(mm)
0
100
200
300
400
500
600

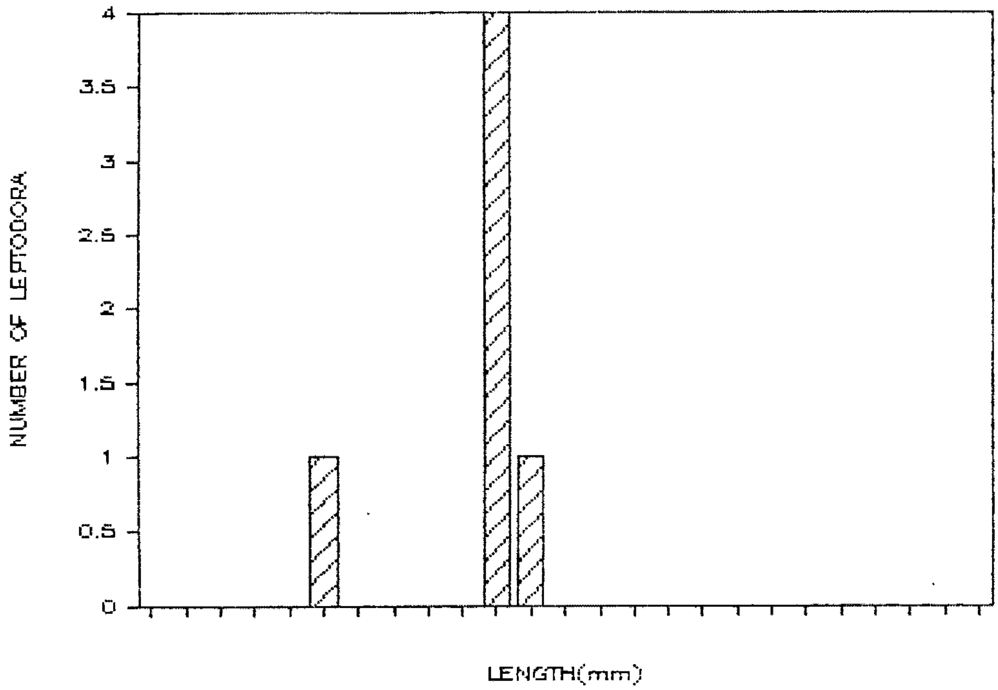
10 M Station 08/25/86



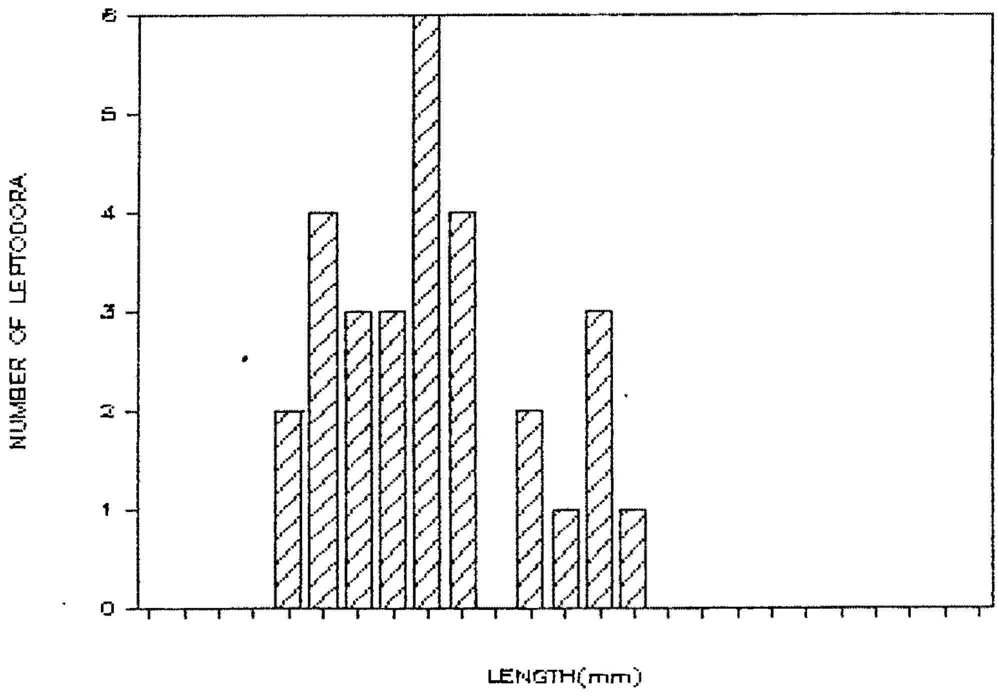
10 M Station 09/08/86

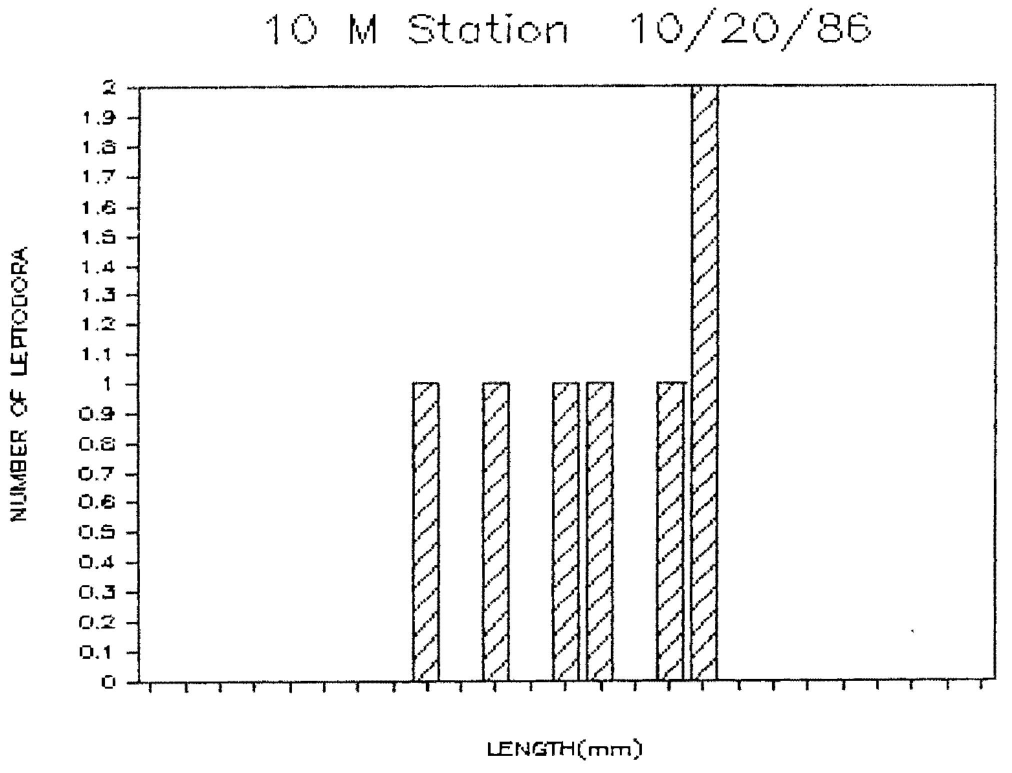


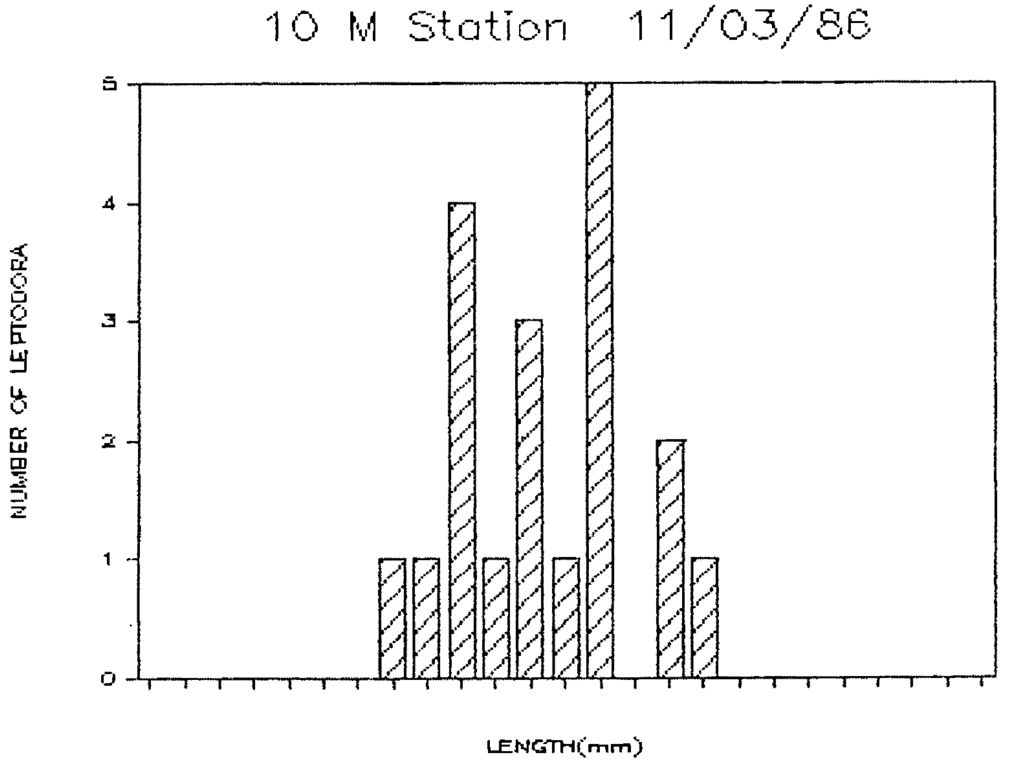
10 M Station 09/22/86

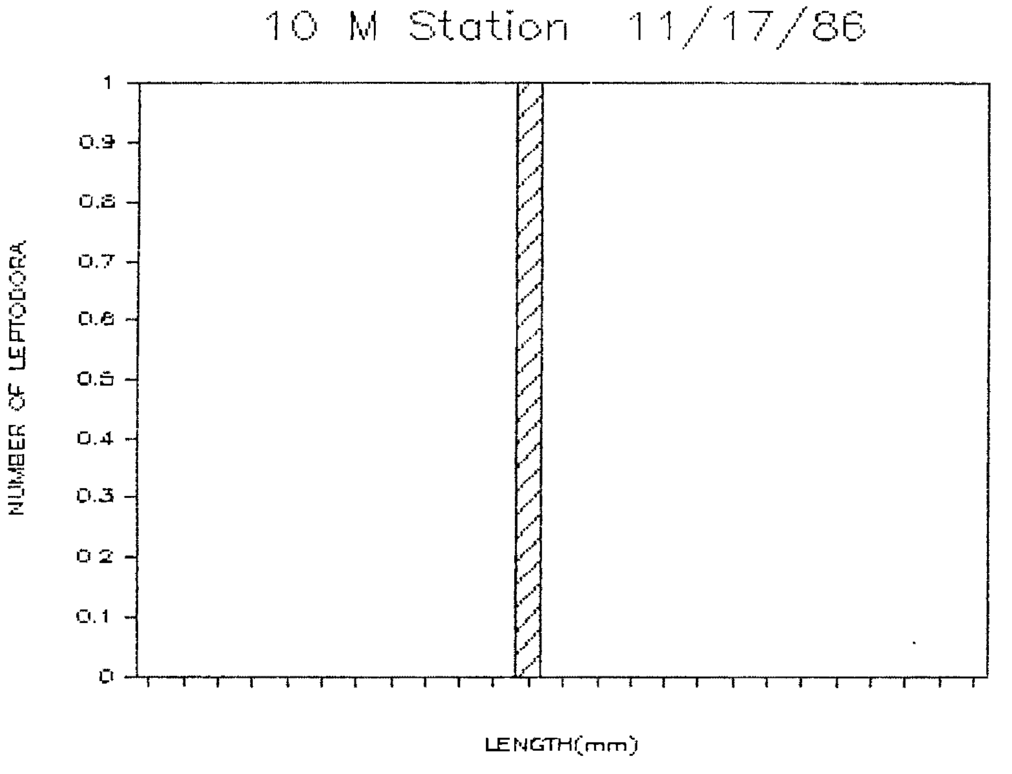


10 M Station 10/07/86



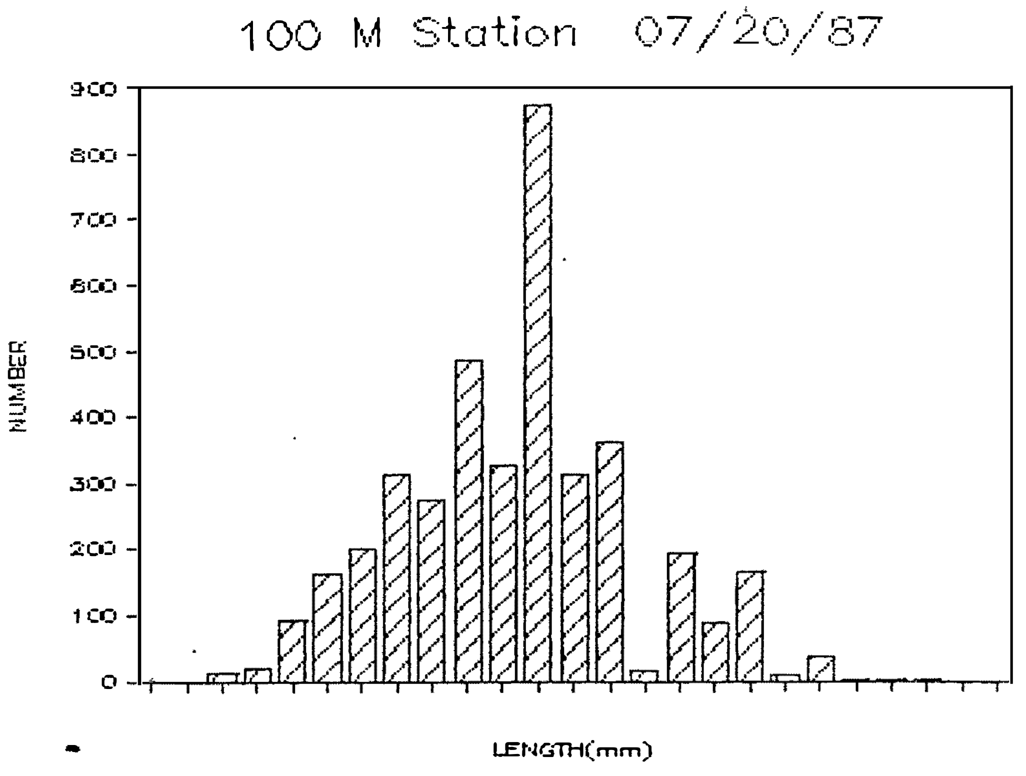

10 M Station 10/20/86
NUMBER OF LEPTODORA
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
LENGTH(mm)

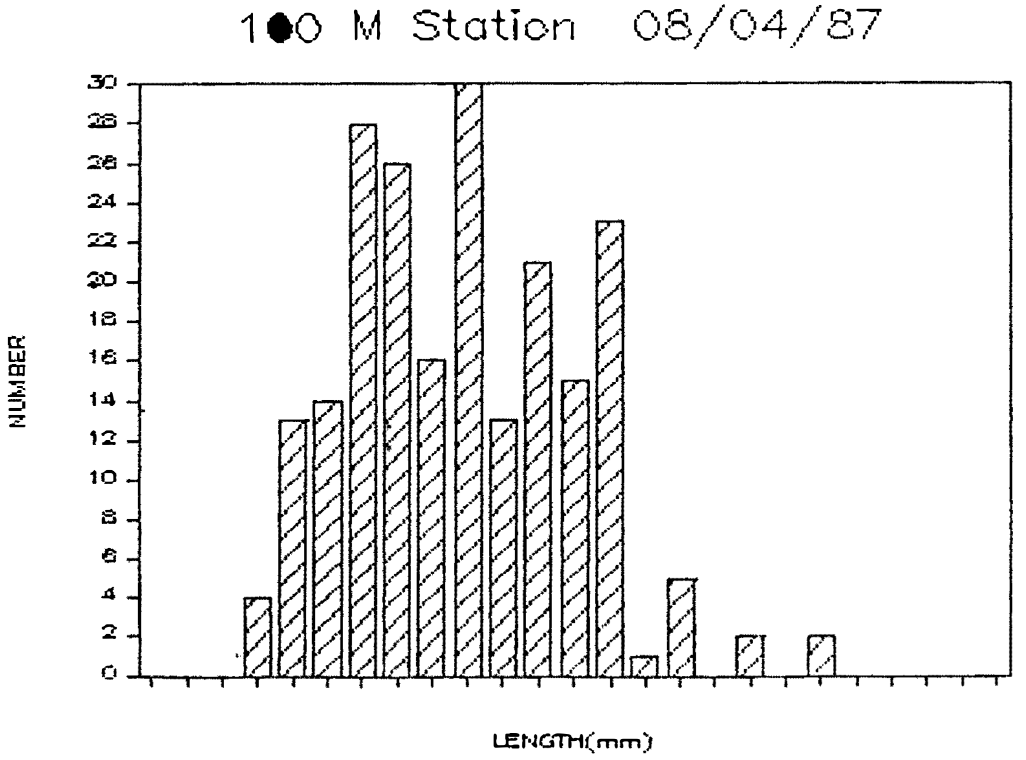

10 M Station 11/03/86
NUMBER OF LEPTODORA
5
4
3
2
1
0
LENGTH(mm)

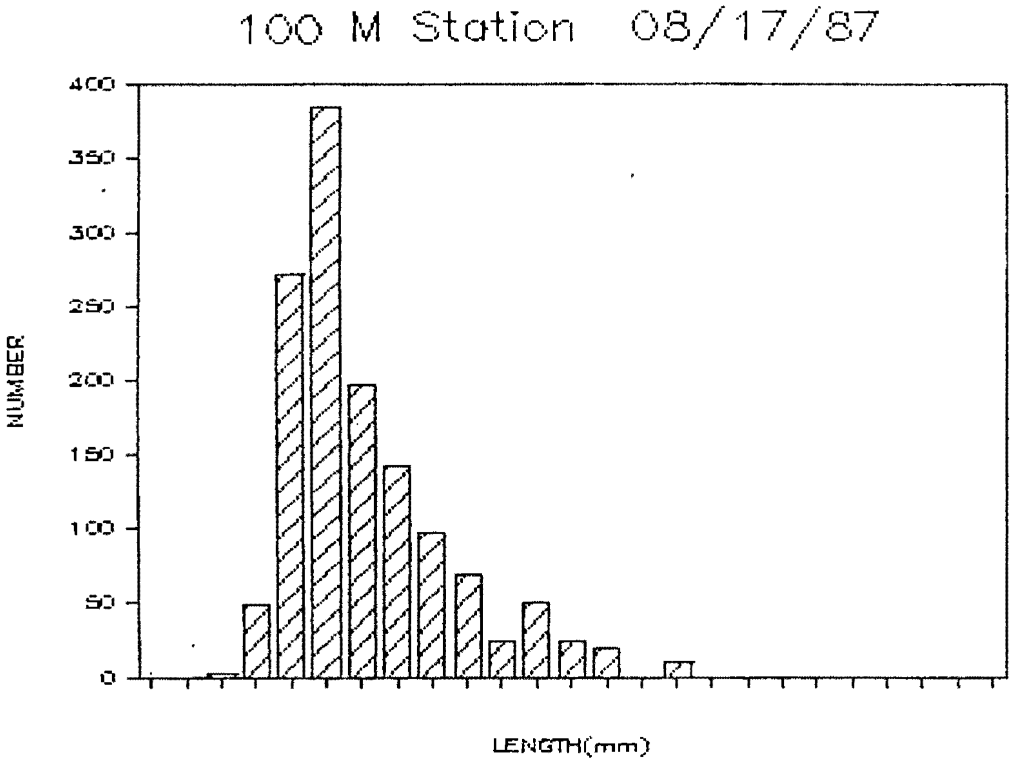

10 M Station 11/17/86
NUMBER OF LEPTODORA
LENGTH(mm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

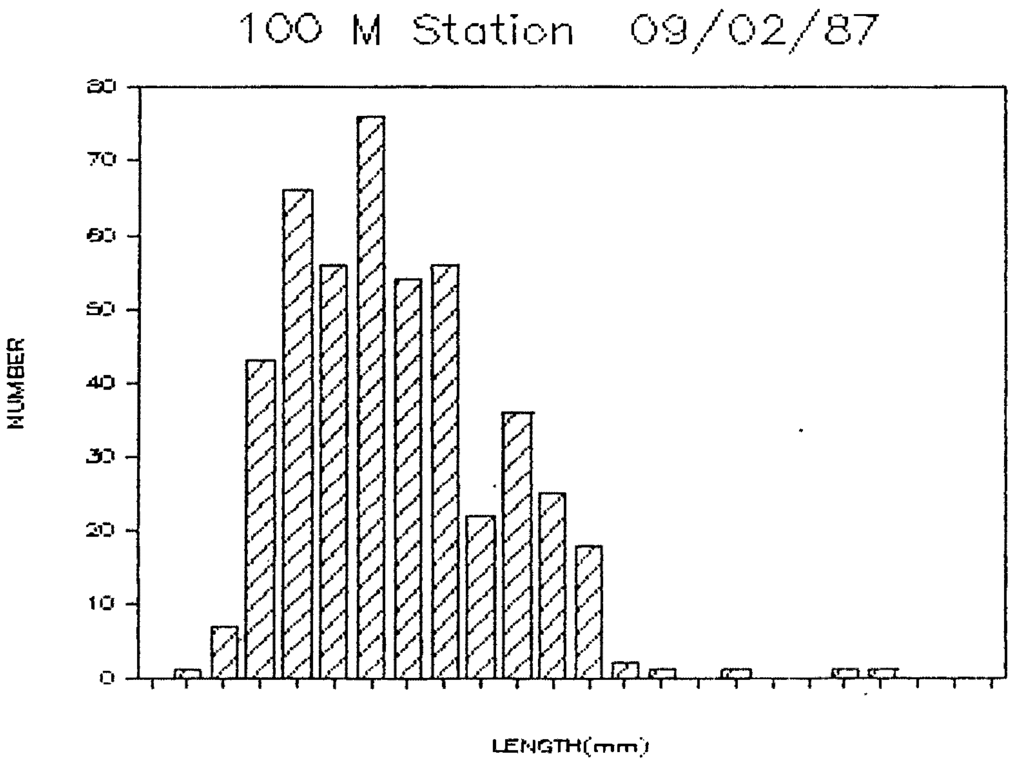
APPENDIX 5

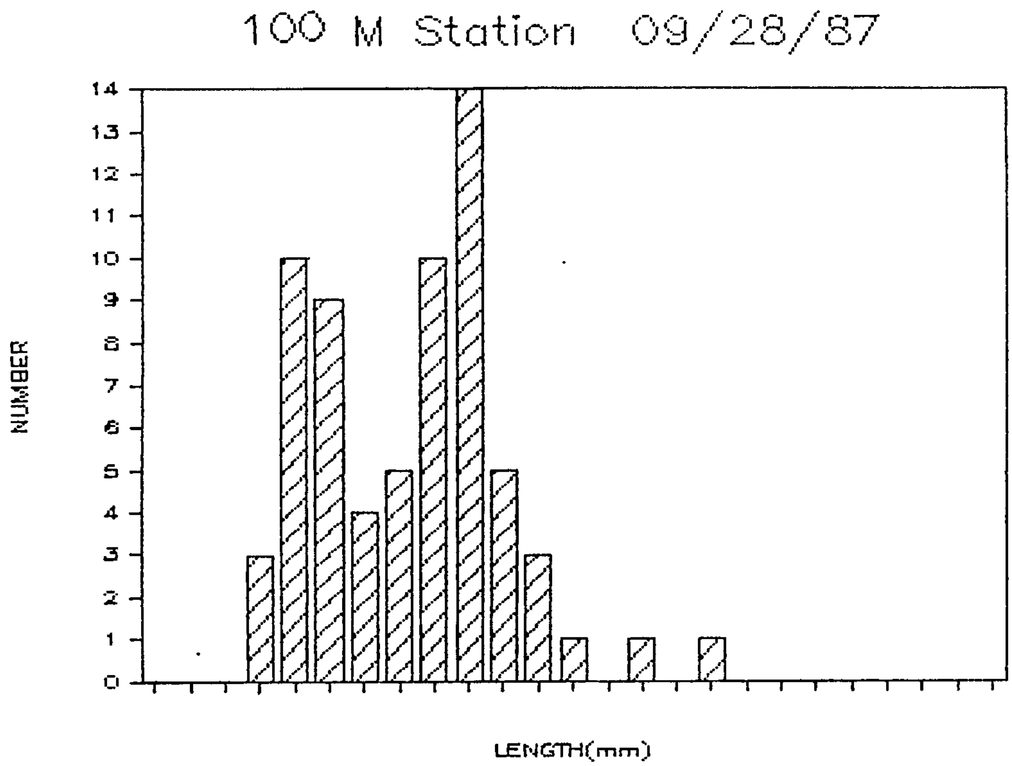
Size frequency diagrams of *Leptodora kindtii* at the 100 m station in 1987

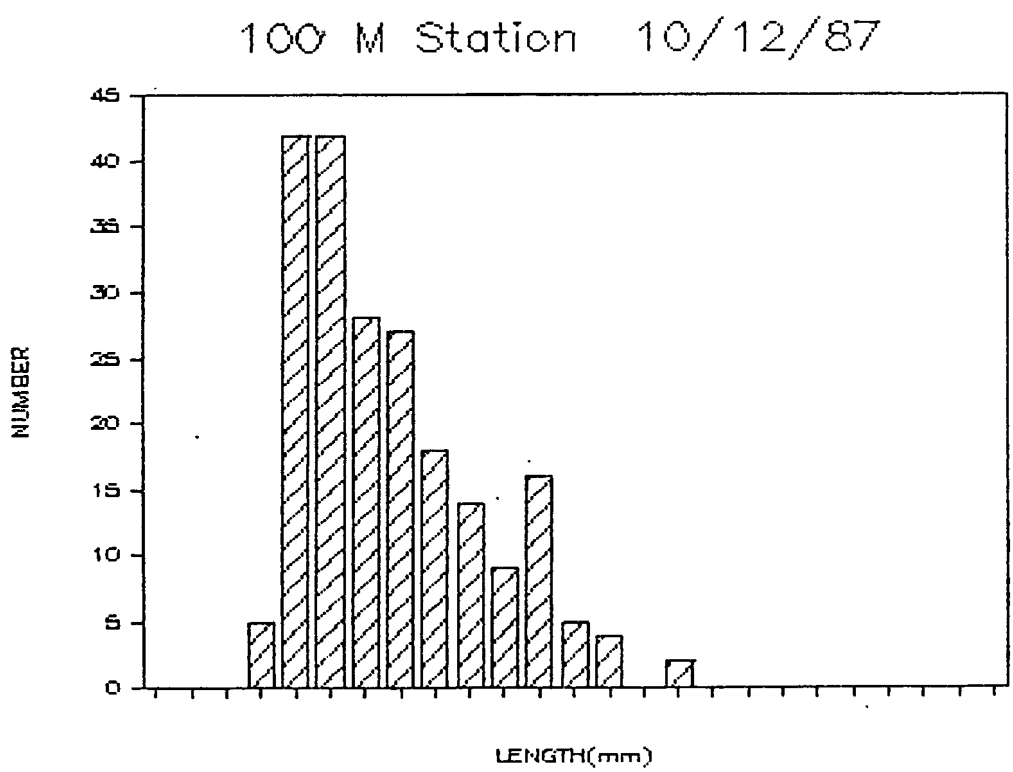

100 M Station 07/20/87
900
800
700
600
500
400
300
200
100
0
NUMBER
LENGTH(mm)


100 M Station 08/04/87
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
NUMBER
LENGTH(mm)

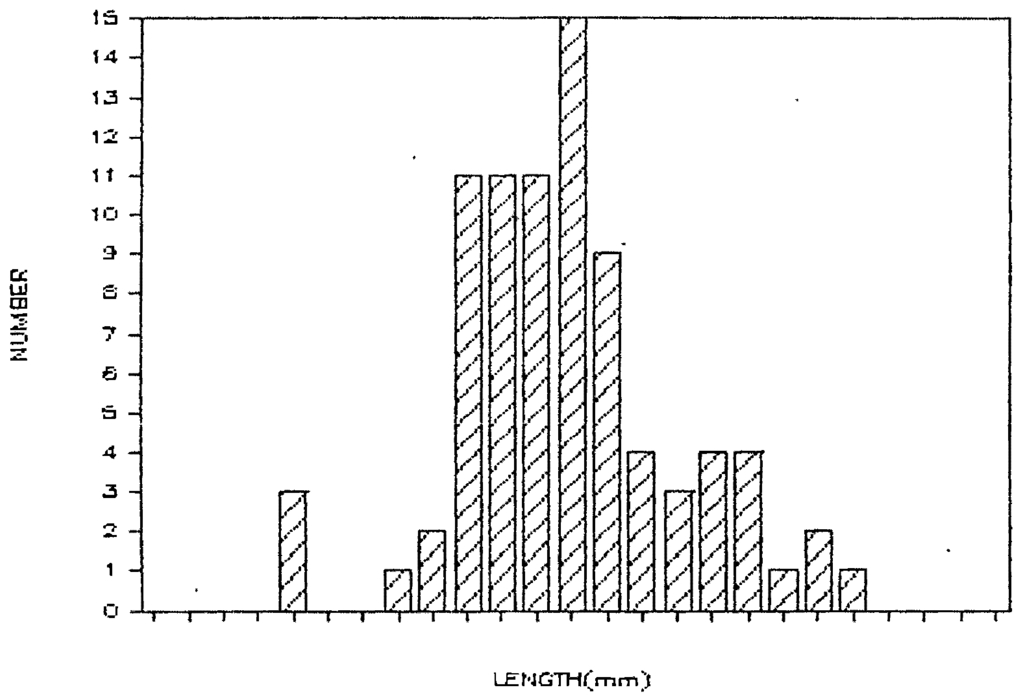

100 M Station 08/17/87
400
350
300
250
200
150
100
50
0
NUMBER
LENGTH(mm)


100 M Station 09/02/87
80
70
60
50
40
30
20
10
0
NUMBER
LENGTH(mm)

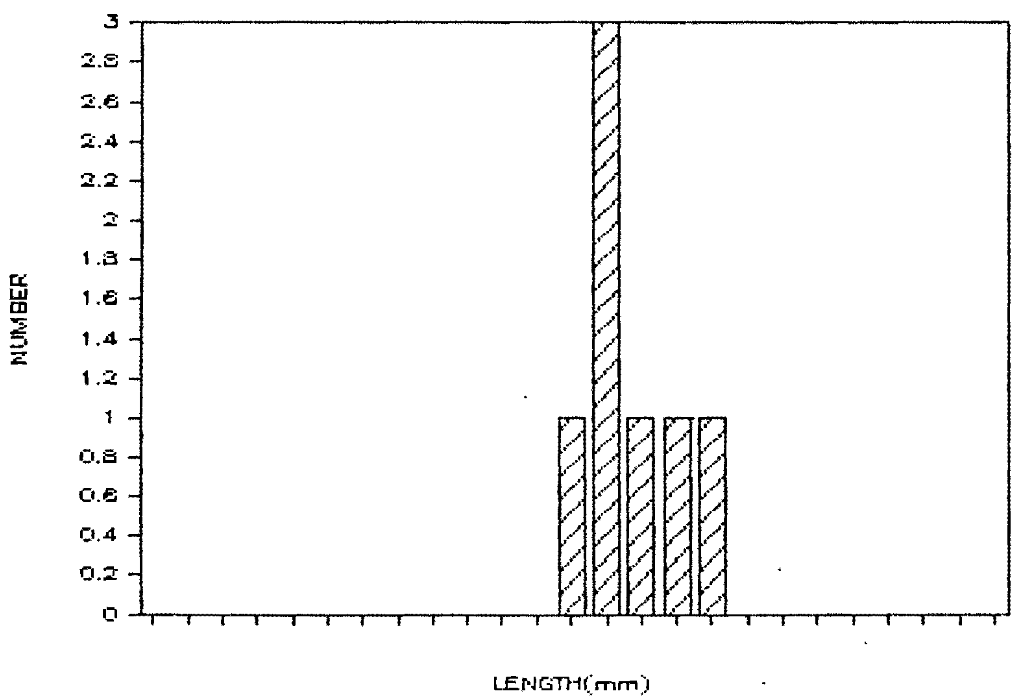

100 M Station 09/28/87
NUMBER
LENGTH(mm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

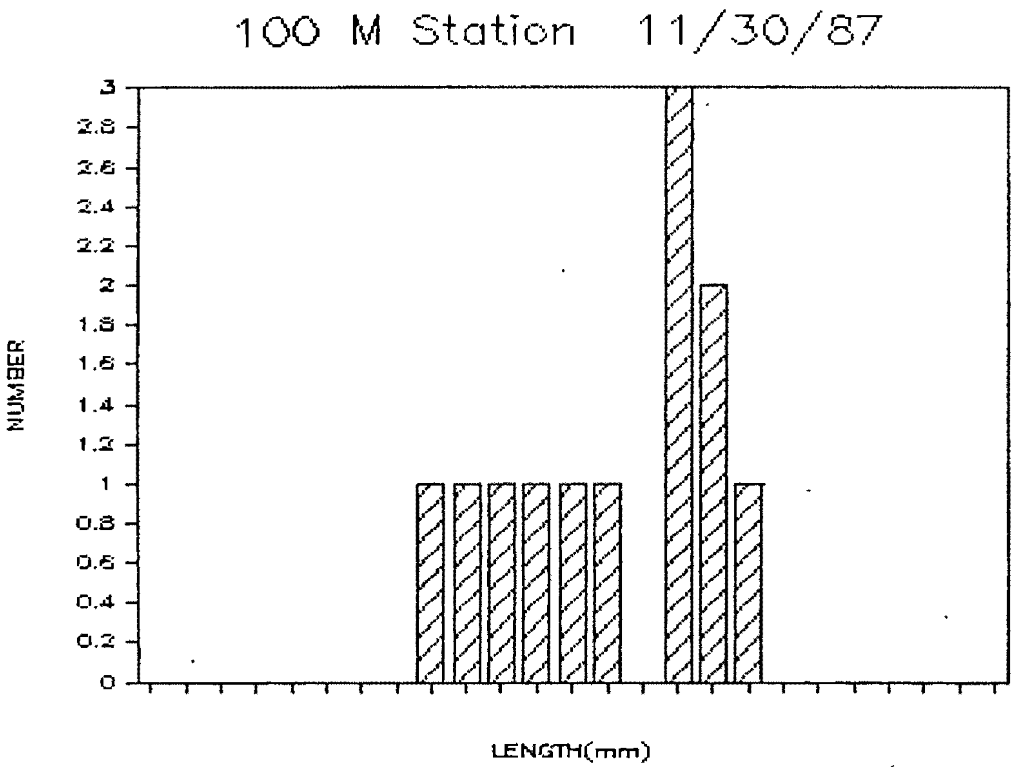

100 M Station 10/12/87
NUMBER
LENGTH(mm)
0
5
10
15
20
25
30
35
40
45

100 M Station 10/26/87



100 M Station 11/16/87




100 M Station 11/30/87
NUMBER
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
LENGTH(mm)

Appendix 6. Seasonal temperature profile performance at the 10 m station in 1986.

DEPTH (m)	SEASONAL TEMPERATURE MEASUREMENT (^{o}C)														
	MAY19	JUN03	JUN16	JUN30	JUL14	JUL28	AUG11	AUG25	SEP08	SEP22	OCT07	OCT20	NOV03	NOV17	DES02
0	8.0	13.6	10.5	17.7	11.4	23.5	21.1	18.0	17.7	10.9	14.4	12.2	10.9	8.1	2.3
1	8.0	13.5	10.5	17.7	11.5	23.5	21.1	18.0	17.7	10.7	14.4	12.3	10.9	8.1	2.2
2	8.0	13.5	10.3	17.7	11.5	23.5	21.2	18.1	17.7	10.3	14.4	12.3	10.8	8.1	2.3
3	7.9	13.3	10.0	17.7	11.4	23.5	21.2	18.2	17.8	9.0	14.4	12.3	10.8	8.1	2.1
4	7.9	13.1	9.5	17.6	10.9	23.5	21.3	18.1	17.8	6.9	14.4	12.3	10.9	8.1	1.8
5	7.8	12.9	9.3	17.6	10.3	23.5	21.3	18.0	17.7	5.9	14.4	12.3	10.9	8.1	1.8
6	7.4	12.7	9.3	17.5	9.0	23.0	21.3	17.9	17.7	5.1	14.1	12.3	10.9	8.1	1.7
7	7.1	11.7	9.3	17.5	8.7	22.9	21.3	17.8	17.7	4.4	14.1	12.3	10.8	8.0	1.7
8	6.8	11.7	9.2	17.5	8.6	22.8	21.2	17.6	17.7	4.3	13.9	12.3	10.6	8.0	1.7
9	6.7	11.6	9.2	17.4	8.6	22.8	21.2	16.7	17.5	4.3	13.9	12.3	10.3	7.9	1.7
10	6.7	11.6	9.2	17.3	8.6	22.5	21.2	16.6	17.3	4.2	13.7	12.3	10.3	7.7	1.7
TAT	7.0	12.3	9.3	17.4	9.3	23.0	21.2	17.7	17.7	5.5	14.2	12.3	10.6	8.0	1.7
TDT 1:	7.2	9.7	7.5	8.1	6.3	8.6	8.3	8.8	10.7	9.5	9.6	9.8	6.1	10.8	6.1
2:	4.4	7.9	5.9	4.3	7.3	8.0	7.4	9.8	7.7	8.3	12.1	6.3	6.9	6.9	5.8
3:	10.1	6.2	7.5	7.1	8.7	7.3	8.5	-	9.8	6.8	10.8	7.9	9.1	8.8	6.3

TAT is a Total Average Temperature (^{o}C) that is calculated base on the average of the biweekly TDT.

TDT refers to Triplicate of Distance Towing (m) or hauling the sampler along the water column.

$$\text{Distance (m)} = \frac{26873 \text{ X Total Revolution of Wheel Meter}}{999999}$$

Appendix 7. Seasonal temperature profile performance at the 100 m station in 1987. See Appendix 6 for TAT and TDT.

DEPTH (m)	SEASONAL TEMPERATURE MEASUREMENT (°C)														
	MAY25	JUN10	JUN22	JUL06	JUL20	AUG04	AUG17	SEP02	SEP14	SEP28	OCT12	OCT26	NOV16	NOV30	DES14
0	9.5	11.5	16.0	19.2	22.0	23.0	22.2	19.0	18.0	17.0	13.0	11.0	8.9	7.0	5.0
2	9.5	11.5	12.0	18.7	22.0	23.0	22.2	19.0	18.0	17.0	13.0	11.0	8.9	7.0	5.0
4	9.4	11.4	10.1	17.6	21.6	22.1	22.2	19.0	18.0	16.9	13.0	11.0	8.9	7.0	5.0
6	9.0	11.3	9.9	17.4	21.1	19.1	21.9	19.0	18.0	16.9	13.0	11.0	8.9	7.0	5.0
8	8.6	11.1	8.9	17.1	20.8	17.0	21.0	19.0	17.5	16.2	13.0	11.0	8.9	7.0	5.0
10	8.0	11.0	8.5	17.0	20.0	15.4	20.0	19.0	17.0	15.0	13.0	11.0	8.9	7.0	5.0
12	7.7	10.9	8.2	12.8	17.0	9.0	19.5	19.0	16.6	14.6	13.0	11.0	8.9	7.0	5.0
14	7.3	10.8	7.5	10.5	13.0	7.5	18.0	18.6	16.1	14.3	13.0	11.0	8.9	7.0	5.0
16	7.0	10.8	7.1	9.5	10.5	6.0	16.5	15.5	15.0	13.7	13.0	11.0	8.9	6.9	5.0
18	6.7	10.7	6.8	8.1	9.1	5.5	15.0	14.5	14.0	12.8	13.0	11.0	8.9	6.6	5.0
20	6.0	10.7	6.6	6.9	8.6	5.3	12.4	11.9	11.8	12.5	13.0	11.0	8.9	6.0	5.0
22	5.7	10.6	5.4	6.5	8.2	5.1	9.5	10.7	9.1	11.6	13.0	11.0	8.9	5.8	5.0
24	5.4	10.6	5.2	6.1	7.9	4.9	7.9	10.1	8.7	10.5	13.0	11.0	8.9	5.7	5.0
26	5.2	10.5	5.1	5.8	7.7	4.9	7.5	9.7	8.4	9.2	13.0	11.0	8.9	5.6	5.0
28	5.1	10.5	5.0	5.3	6.6	4.8	6.6	9.1	7.9	8.1	13.0	11.0	8.9	5.6	5.0
30	5.0	10.5	4.9	5.0	6.0	4.7	5.7	7.6	7.5	7.2	13.0	11.0	8.9	5.5	5.0
35	4.7	9.9	4.6	4.1	4.9	4.5	5.0	6.5	6.4	5.5	13.0	11.0	8.9	4.9	5.0
40	4.3	6.4	4.5	3.9	4.6	4.3	4.5	5.6	6.0	4.5	9.1	10.5	8.8	4.1	5.0
45	4.2	4.7	4.4	3.7	4.4	4.2	4.3	5.1	5.5	4.2	6.5	9.5	8.7	4.0	5.0
50	4.1	4.5	4.3	3.5	4.2	4.1	4.1	4.0	5.0	4.1	4.5	7.7	8.6	4.0	5.0
TAT	6.6	10.0	7.3	9.9	12.0	9.7	13.3	13.1	12.2	11.6	12.1	10.7	8.9	6.0	5.0
TDT 1	31.1	32.6	39.7	40.0	34.8	47.6	26.9	44.5	49.5	27.0	44.8	13.4	21.2	25.2	22.4
2	28.7	25.1	38.8	40.5	39.8	56.1	31.7	40.5	29.3	21.0	13.9	14.3	17.3	11.8	-
3	15.8	36.2	41.1	41.8	41.1	51.9	34.2	33.9	36.9	17.5	12.4	18.3	11.8	12.6	-